THE COMPLETE MOTORIST

BY

FILSON YOUNG

AND

W. GORDON ASTON

WITH A LETTER FROM RUDYARD KIPLING

WITH 14 DIAGRAMS AND 24 ILLUSTRATIONS

EIGHTH EDITION, REVISED

METHUEN & CO. LTD.
36 ESSEX STREET W.C.
LONDON

First Published	*September*	*1904*
Second Edition (Revised)	*October*	*1904*
Third Edition	*November*	*1904*
Fourth Edition	*March*	*1905*
Fifth Edition (Revised)	*October*	*1905*
Sixth Edition	*April*	*1906*
Seventh Edition (Revised)	*November*	*1907*
Eighth Edition (Rewritten and Revised)	*October*	*1915*

This Edition, with the exception of the letter from Rudyard Kipling and Chapter VI (The Open Road), has been completely rewritten.

CONTENTS

CHAPTER IV

LIST OF ILLUSTRATIONS

THE COMPLETE MOTORIST

THE COMPLETE MOTORIST

A LETTER FROM RUDYARD KIPLING

CAPETOWN
April 1904

DEAR FILSON YOUNG,

I like motoring because I have suffered for its sake. I began seven years ago in the days of tube ignition, when 6 h.p. was reckoned fair allowance for a touring car, and fifteen miles an hour was something to talk about. My agonies, shames, delays, rages, chills, parboilings, road-walkings, water-drawings, burns, and starvations, at which you laughed—in the *Kinfauns Castle* in 1900—all went to make your car to-day safe and comfortable. If there were no dogs there would be no vivisection, and people would still be treated on the lines of Galen and Avicenna. Any fool can invent anything, as any fool can wait to buy the invention when it is thoroughly perfected; but the men to reverence, to admire, to write odes and erect statues to, are those Prometheuses and Ixions (maniacs, you used to call us) who chase the

inchoate idea to fixity up and down the King's Highway with their red right shoulders to the wheel.

Yes, I love because I have suffered. Suffered, as I now see, in the cause of Humanity.

You ask how the motor has helped me? In the first years it was you and the likes of you that I was helping, for all my real progress over the ground was by fly or in the chance-met dung-cart. The early Neo-Gallic car did no more than raise me to a nobler plane of thought. I have heard men of the new generation—late-comers to a game made easy—use language over a faulty spark or a stuck valve that would almost disgrace the childish golfer. My mouth was emptied of these vanities long ago. I can spend three hours in dark and cold with a leaky tube that needs attention every two hundred yards, and a virgin may listen to my every word. But of the Moral Aspect of Things hereafter.

Nowadays, my car helps me to live at a decent distance from any town without sacrificing what house-agents call the amenities. I am rid of the whole tribe of coachmen, saddlers, corn-dealers, smiths, and vets. I can catch me a train anywhere within fifteen miles when I please, and not when the Jenny's hind leg or Jack's cough is better; and if I visit, I do so as a free agent, making my own arrangements for coming and going. In all cross-country journeys I am from one to four hours quicker than the local train

service. On main line routes I hold my own—in greater comfort than the railway can give me—up to forty miles.

But the chief end of my car, so far as I am concerned, is the discovery of England. To me it is a land full of stupefying marvels and mysteries; and a day in the car in an English county is a day in some fairy museum where all the exhibits are alive and real and yet none the less delightfully mixed up with books. For instance, in six hours, I can go from the land of the *Ingoldsby Legends* by way of the Norman Conquest and the Barons' War into Richard Jefferies' country, and so through the Regency, one of Arthur Young's less-known tours, and *Celia's Arbour*, into Gilbert White's territory. Horses, after all, are only horses; but the car is a time-machine on which one can slide from one century to another at no more trouble than the pushing forward of a lever. On a morning I have seen the Assizes, javelin-men and all, come into a cathedral town; by noon I was skirting a new-built convent for expelled French nuns; before sundown I was watching the Channel Fleet off Selsea Bill, and after dark I nearly broke a fox's back on a Roman road. You who were born and bred in the land naturally take such trifles for granted, but to me it is still miraculous that if I want petrol in a hurry I must either pass the place where Sir John Lade lived, or the garden where Jack Cade was killed. In Africa one has only to put the miles under and go on; but in England

the dead, twelve coffin deep, clutch hold of my wheels at every turn, till I sometimes wonder that the very road does not bleed. *That* is the real joy of motoring—the exploration of this amazing England.

But to revert to the Moral Aspect; and in continuation of some of my remarks on the *Kinfauns*. Have you noticed how the motor is the most efficient temperance advocate, and the only Education Act at present enforced, in Great Britain? A horse in most harnesses does the work for which his driver is paid; and when the man is more than usual drunk the beast will steer him home. Not so the car. She demands of her driver a certain standard of education, the capacity of unflickering attention, and absolute sobriety. Failure to comply with her indent means death, mutilation, or fine in the shape of a heavy repair bill. There is no argument: there is no concession: above all, there are no carrots. She is a condition, not a theory. Think what her presence, in registered thousands, will mean to a nation which has been laboriously trained never to admit the existence of a condition if that condition conflicts or seems likely to conflict with any one of its theories! Even now I see improvement. There are on the twenty odd miles which divide me from the nearest town westward thirty-one or thirty-seven pubs. In front of each I used to find at least two unattended horses. Now there are fewer beasts outside, and those within are not so

sodden. They keep one ear up the road; they set down their tankards; they leap from the bar; they run to their horses' heads. They break, if it be but for an instant, the habit of ages. What has wrought the change in our midst? Tracts? Blue Ribbons? The Fifth Standard? That would not be the Te-rewth. It is the Car—the Unexpected Car round the corner.

I have seen carriers, awake and erect on their seats by the hour, both reins in their hands and both eyes on their pair. I have seen the fat coachman of the fat landaus and barouches that bumble round the country-side visibly driving—a thing which, the horses attested, they had not done for years. I have seen the whole of a hunting-field sit down and really ride their mounts. Some of them did it very badly but they all tried. I have seen men walking on the roads suddenly and accurately distinguish between their left hand and their right, and this not for political reasons, as a tenet of religion or as a form of sport, but automatically and almost as though it were the ingrained instinct of a highly organized civilization. Seven years ago accuracy, precision, restraint, the idea of projecting one's imagination a hundred yards ahead of one's nose down an apparently empty road did not exist. It is the Car, my dear Young, that we have to thank for the quickened intellect, the alerter eye, the more agile limbs, and the less unquenchable thirst of our fellow-citizens, as well as for the higher standard of decency now attained

by our officially dumb companions. I know a rooster on the Heathfield Road who, but that he is honest, might be made constable over a trap. He can judge to a fraction the speed of every motor that comes his way, and since he has no tail to speak of he takes chances that bring the heart into your mouth. But he survives, and I do not doubt will be the sire of a line of double-breasted, facing-both-ways poultry. And there is a dog who was once bold against the bare legs of children and the skirts of nurses—the sort of ravening hound of whom his owner says, "It's only his play. He won't hurt you unless you show you're afraid of him." Last year my car caught him on the shoulder and hoisted him nearly as high as Sirius. He came down again quite well, thank you, but so changed—and so vastly for the better! He, too, will propagate polite puppies.

Thus do we all benefit by the Note of the Age, which is the motor-horn.

As the English mail is just closing and I want to go for a trip to Stellenbosch I will spare you the rest of the sermon. The subject is inexhaustible, but I am,

Yours ever considerately,

RUDYARD KIPLING

CHAPTER I

THE EVOLUTION OF THE MOTOR-CAR

A wandering idea—Leonardo da Vinci—Sir Isaac Newton's car—Steam carriages in the eighteenth century—An early French car—James Watt—The Victorian era—Gurney's difficulties—The first motor omnibus—Gottlieb Daimler—The discovery of the gas engine—The first Panhard—Peugeot and Benz—Serpollet and De Dion—The great race of 1894—The Paris-Bordeaux Race—The Automobile Club of France—Light Locomotives Act, 1896—Founding of *The Autocar*—Invention of the pneumatic tyre

TO move about from place to place without the trouble of walking has been the luxurious necessity of man ever since he first began to enjoy the fruits of knowledge. For a long time it was enough that some fellow-creature, man or beast, should toil and sweat at his bidding, and drag him about wheresoever his fancy suggested. But there came other dreams, other ideas of luxury. A carriage that would go by itself; a magic chair that would transport its occupant from place to place, proceeding by invisible machinery, and moved apparently by its own volition; there was a majesty, a glorious impossibility, a splendid disdain of limitations in that idea that must have inspired its first entertainer with an almost intoxicating pride. Even to-day, when the thing is a commonplace, and a

matter of universal experience, the embers of that fire of enthusiasm which consumed the minds of ancient philosophers still remain. It is kindled largely by the demand for independence; by the desire to feel that the motive power, of which one avails oneself, is due to human initiative and invention. Moreover, the carriage that goes by itself must essentially possess the advantage of being under the complete control of its user. Instead of having a will of its own to direct its strength towards an end which the possessor does not wish to attain, its function is merely implicitly to obey. Many thousands of generations had passed into dust before the idea that any natural energy existed beyond that which is incidental to the muscular action of animals was formulated. The two great elements, wind and water, obviously possessed great powers of destruction, but it must have been long after this fact was realized that the problem of making so much wasted energy perform work useful to mankind was tackled with any seriousness. Probably the first locomotive that moved without the aid of any muscular effort at all was a crude ship, and the same principle of obtaining work from the wind was, in the course of evolution, employed in the construction of the windmill. Such simple mechanical devices involved an equally simple theory, and it is not surprising therefore to find that they had been in existence many many years before pioneer scientists arrived at the conclusion that heat was also a form of energy that could be brought

into the service of mankind. Long before anything practical was accomplished, sketches of self-propelled vehicles had been outlined by visionaries, and Leonardo da Vinci actually made some rough plans for an autocar in the fifteenth century. Two hundred years later the idea of self-propelled locomotion began to be busy in the western world, and rooted itself no longer in the minds of individuals who are far in advance of their time, but in the common mind of the age. The first engineer to attempt the problem in a practical manner was the mathematician Simon Stevin, who in the year 1600 constructed a wind carriage, which carried twenty-eight persons along the coast from Scheveningen to Petten at an average speed of twenty-one miles an hour. Notable amongst its passengers on this trip were Prince Maurice and his prisoner, the Spanish Admiral Mendoza. This machine was practically a boat on four wooden wheels, and a similar model of a smaller size, also built by Stevin, is referred to in *Tristram Shandy*. About eighteen years later Thomas Wyldgoose, an Englishman, took out a number of patents for various vehicles, which were to be drawn without horses or sails. The mechanism is not described, but it is almost certain to have been some kind of manual gear. Such vehicles do not, of course, strictly belong to the class which is being considered, but that they were regarded as worthy of research is proved by the number of engineers about that time who devoted their attention to them.

A large carriage for running on ordinary roads was built in Nuremberg by Johann Hautsch, and was purchased by the Crown Prince of Sweden. It was neither more nor less than a gorgeous toy, and was worked by men who were concealed in the interior, the externals consisting of stately carving and ingenious decoration. Its speed is said to have been about two miles an hour. In the same category comes a mechanical chair on four wheels, which was contrived by Sir Isaac Newton in 1655, whilst in the previous year Hooke had taken out a patent for a single-wheeled vehicle, presumably operated by the movements of a rider situated inside the wheel itself. Richard, a French physician and scientist, produced a carriage in which a treadle gear, operated by a servant in the rear of the vehicle, was caused to propel it. In 1710 practically no progress had been made, except that in the meantime Sir Humphrey Mackworth proposed the application of sails to colliery wagons travelling on a tramway. In the year named a similar machine to Sir Isaac Newton's carriage already described was made by Monsieur Beza, a French physician, and chiefly intended for the use of invalids. A new use of the wind in the propelling of road wagons was tried in France by Monsieur du Quet in 1714. This inventor employed a windmill, which transmitted motion to a pair of legs fixed on either side of the wagon, and adapted to thrust it forward; whilst a still further improvement was described in 1760 by the Rev. J. H. Genevois, a

Swiss clergyman, who proposed to use either a windmill or sails that should store energy in the carriage by means of springs, which could be used when the wind failed. Gradually, the conception of sailing on dry land was perceived to have very narrow limitations, and early in the eighteenth century the idea seems to have been dropped. It is interesting to note that wind wagons are used as a rather strenuous form of pleasure vehicle to-day in many places where a hard dry seashore is available.

It was not until late in the eighteenth century that any attempt was made to apply steam to road carriages, although much was done in evolving a sound method of employing its properties in other engineering work. Newcomen and James Watt were busy on the cylinder and piston, but it was not until the year 1769 that it occurred to any one to make some attempt to turn the reciprocating motion of the piston into a rotary movement which could be applied to the propelling of the vehicle. Nicholas Joseph Cugnot, a French military engineer, designed and built in this year a steam carriage, in which this principle was applied. The machine still exists, and may be seen at the Conservatoire des Arts et Métiers, whilst a scale model of it has been erected in South Kensington Museum. A second machine was built, but for political reasons was never tried, though the first had travelled on a common road and successfully attained a speed of 2¼ miles per hour, carrying four

persons. The boiler capacity was insufficient, however, to enable it to run for more than fifteen minutes without pausing to get up steam again. Cugnot's vehicle, which is of great interest as being the first practical road motor-car, is in reality a heavy three-wheeled lorry, with all its mechanism carried over the single front wheel, which is steerable.

After this invention France contributed nothing to the development of auto locomotion for a full century, but a considerable amount of work was done in England. Richard Trevithick, who was engaged in adapting Watt's steam engine to the work of pumping water out of mines, constructed in 1800 the first self-propelled carriage to carry people on English roads. James Watt had also entertained similar notions, but was at best half-hearted and very doubtful as to ultimate success. In 1784 his assistant, William Murdock, had constructed a model steam carriage of a very simple type, which is particularly interesting, because it contained the first application of the crank to transform the linear motion of the piston into a rotary motion. This model was tried on the road one dark night in the village of Redruth in Cornwall, and nearly frightened the village parson, who took it to be the devil, out of his wits, as it had run away from its inventor. In 1796 Murdock informed his principals, Boulton and Watt, that he had succeeded in constructing a satisfactory steam carriage, but this so alarmed

the jealous Watt that he found work for his clever assistant which kept him otherwise closely occupied. In the same year Trevithick's first model, which was a three-wheeler, was produced, and in 1801 the experiment had developed so successfully that the construction of a full-sized carriage was put in hand, and the vehicle made its trial trip on Christmas Eve. Carrying seven or eight people, it was driven up Camborne Beacon for half a mile, faster than a man could walk. In the next year a patent was taken out for an improved carriage, in which, instead of coupling the wheels direct to the piston, he employed a crank shaft, which was geared to the road wheels by spur pinions. Trevithick anticipated the modern change-speed gear in pointing out that "the power of the engine, with regard to its convenient application to the carriage, may be varied by changing the relative velocity of rotation of the road wheels, compared with that of the crank axis, by shifting the gears, or toothed wheels, for others of different sizes, properly adapted to each other." Unfortunately Trevithick soon discontinued his experiments in road locomotion, and after turning his attention to tramways and railway engines, and finding scant encouragement, he abandoned locomotive engineering altogether. With Trevithick and the eighteenth century the first period of experiment in self-propelled carriages may be said to have ended, for the condition of the English roads was such that even had a practical steam road carriage

been built its use would have been almost impossible, and for further progress principal credit is due to those great road engineers, Telford and Macadam, who re-organized and re-constructed that system of inter-connected English roadways which stands unique as a national possession and is the envy of every other civilized country in the world. The new interest which the work of these road engineers gave to mechanical invention, as applied to self-propelled carriages, resulted in a tremendous volume of activity, and indeed between the years 1832 and 1838 there were not far short of a dozen companies formed to work lines with steam coaches, both over short and long distances. There was a dearth of engineers working at steam carriages to supply this demand. The vehicles of Griffiths, of Gordon, of Brunton, of Birstall and Hill, of Chambers and Anderson, of Henry Peto, and of James Nasmyth were all improvements on anything that had been done before, and many of them successfully carried heavy loads of passengers, but it was not until Goldsworthy Gurney, who as a boy had seen Trevithick working with his models, turned his attention to the construction of steam coaches that they came into use as public conveyances.

In 1827 he constructed a large coach for twenty-one passengers. To this he fitted propelling legs in addition to the usual mechanism for driving the wheels, as he was afraid that the latter would have insufficient grip on the road surface. It was soon

seen, however, that any such provision was unnecessary. This carriage is said to have attained a speed of fifteen miles an hour, and was, considering the times, highly successful in every way. Gurney, like many pioneers, had to put up with a good deal of stupid opposition and open hostility. On one journey which he made to Bath with a number of guests his carriage was attacked at Melksham, where there happened to be a fair. The people formed such a dense mass that it was impossible to move the carriage through them. The crowd being mainly composed of agricultural labourers, considered all machinery directly injurious to their interests, and set upon the carriage and its occupants, seriously injuring Mr. Gurney and his assistant engineer. Not to be discouraged by this adventure, Gurney continued his work, and in 1831 Sir Charles Dance, in spite of hostile local feeling, started a service of steam carriages between Cheltenham and Gloucester, and the steam coaches, after making some 400 journeys, actually earned a profit, and continued until 1840, when the service was killed by the imposition of ruinously heavy tolls on self-propelled vehicles. The Government eventually voted to Gurney sixteen thousand pounds in recognition of his public services.

Even more successful was Walter Hancock, whose machines were much more practical and improved than anything that had been made before. He used, for instance, much higher boiler pressure,

and employed forced draught, and a chain drive from his crank shaft to the wheels. Hancock built about ten vehicles, to which he gave such now famous names as "Infant," "Autopsy," "Era," "Enterprise," and "Automaton." Considerable attention was devoted to the comfort of passengers, and a successful service of cars between the City and Paddington was run from 1834 to 1840. Another historic vehicle of this period is Dr. Church's steam coach (1833), a marvellous construction in outline and ornamentation, something between a gipsy van, a merry-go-round, and a ship's saloon. Other successful constructors of coaches were Maceroni and Squire Hill of Deptford, and the Steam Carriage Company of Scotland. In 1840, however, the tolls had increased to such a point that it was impossible to run steam carriages at a profit. The development of railways had about this time also diverted public interest, so that gradually the steam coach disappeared from the roads, and attention was paid instead to the traction engine and the use of mechanical power for driving heavy goods. With the development of this an agitation was raised against the toll laws, and in 1861 provisions were made for a uniform scale throughout the country. These acts, however, regulated the weight and speed of the vehicles, and thus effectually killed passenger carriages.

Thus the industry in which England should have led the world was left to be taken up by other nations. Here and there indeed in this country an

enthusiastic inventor would build a carriage in spite of the laws, or an adventurous citizen would buy and run steam carriages at the risk of fine and imprisonment. The chief makers of these carriages were Rickett, 1861; Carrett, 1861; Yarrow and Hilditch, 1862; Knight, 1868; Catley and Ayres, 1869; Todd, 1879; Randolph, 1872; Blackburn, 1878; and Inshaw, 1881. With the exception of Randolph's design these vehicles presented no very novel or valuable features which had not been already incorporated by Hancock. As an industry the self-propelled road carriage was dead. On the Continent and in America, where jurisdiction had not to be overcome, experimental work still proceeded and attempts were made to employ other motive power than steam. Clockwork was tried without success, whilst compressed air and electricity also proved failures. What we to-day regard as the final solution to the problem was found by Gottlieb Daimler, whose application of the internal combustion to the automobile was destined to revolutionize the whole industry.

Gottlieb Daimler was a mechanical engineer who had worked at his profession with some of the chief firms in England and Germany. In the year 1884, having then been for some time Director of the Otto Gas Engine Works at Deutz, he produced and patented a small gas engine designed to run at very high speeds, so high that the heat generated by it was enough to ignite the charges of gas furnishing the propelling power. A description of

the Otto cycle, which is the principle of all petrol engines, will be found in another part of this book; it is enough to say here that the motive power of such engines is furnished by a series of gas explosions taking place in the cylinder itself, so that the cumbersome attachment of boiler and furnace are done away with. The next year Daimler improved his engine by fitting a heavy flywheel, and by enclosing the crank in a chamber in which a valve capable of opening inwards, but not outwards, was fitted. Through this valve the explosive mixture was automatically drawn by the upstroke of the piston. As soon as the piston began to descend again the valve was closed, and the charge of gas consequently compressed within the crank chamber. Towards the end of the downward stroke a valve fitted in the piston itself was mechanically opened, thus allowing the compressed gas to fill the upper part of the cylinder. As the piston began again to travel upwards the valve in the piston was closed, and when the piston reached the top of its stroke the charge was fired by means of an incandescent tube. In order to keep the cylinder from becoming red hot some form of cooling was necessary, and in Daimler's first engine this was effected by a fan.

In the year 1886 Daimler fitted this engine to a bicycle, by placing it vertically between the front and rear wheels, the latter being driven from the engine by means of a belt. Gas was supplied from a carburettor in which the necessary mixture

of an explosive vapour was effected by causing the air to enter the liquid from below, thus combining with the vapour given off by it. This engine, crude as it was, proved so satisfactory that Daimler continued to work at it, and in 1889 constructed a two-cylinder engine, the piston rods of which were coupled to a single crank. This engine was the first to attract the notice of practical engineers, and to lead them to believe that the explosion engine could successfully be applied to motor-cars. The right to manufacture Daimler's engine was acquired in 1889 by Messrs. Panhard & Levassor, who immediately began the construction of motor-cars as we understand them to-day. The first Panhard car was brought out in 1891, and in that and the following three years they had constructed about a hundred cars. These were driven by Daimler's two-cylinder engine of about the same horse-power as we now apply to the lightest kind of motor-bicycle. They were, however, provided with great improvements in the way of transmission and control. The engine drove a longitudinal horizontal shaft, running beneath the frame, which was connected with a parallel shaft above it by means of cogged wheels of various sizes, thus providing for a change of gearing, and an alteration of the speed of the carriage, while the speed of the engine remained constant. The upper longitudinal shaft drove, by means of a bevel gear, a transverse shaft, which in its turn was coupled by chains at either end to the driving wheel. It may truly be said

that the latest devices used in the most modern car are but an improvement and evolution of the features of those early Panhards.

At the same time the firm of Peugeot Frères was also building cars driven by Daimler motors. Their methods were much the same as Messrs. Panhard & Levassor's, but the cars were somewhat lighter in construction, while the engines, instead of being placed in front as in the Panhard cars, were placed behind. Clutches were also used for throwing the engine in and out of gear, and the Ackermann system of carrying the front wheels on a rigid axle with pivoted ends was used for steering. Rubber tyres were used, and a maximum speed of from ten to twelve miles an hour was attained. The pioneer work of Benz in the motor revival must not be forgotten. Quite independently of Daimler, and at about the same time—1885—he was building a gas engine to be applied to a motor carriage. In his plan, which was retained in the Benz carriages for many years, the engine was placed at the rear of the carriage over the back axle. It drove a vertical crank shaft, the chief object of this arrangement being to ensure stability in the steering of the car by the horizontal position of the flywheel. The crank shaft was connected by bevel gearing to a short horizontal shaft, and this in its turn was coupled by a belt to a horizontal counter-shaft, the ends of which were connected to the road wheels by chains in the usual way. There were fast and loose pulleys for the belt, so that the

engine could be run free when it was desired to stop the car. Benz's cylinders were cooled by a water jacket, and at first were worked on the two-stroke cycle, but in the subsequent development of this engine in collaboration with Roger of Paris, the Otto four-stroke cycle was adopted. These crude, but quite practicable cars did not long lack patrons, and were bought in some considerable numbers by wealthy amateurs. By the year 1894 there were quite a number of carriages which could be driven upon the road at speeds of from ten to fifteen miles an hour with something like a certainty that they would arrive at their destination. Activity in the matter was practically confined to France, as the conditions of the law in England made it quite useless for engineers to spend their time on the development of road locomotion. Some public interest and private enterprise had in 1894 brought matters to such a stage in France, that it was felt some means should be taken to draw together the various threads of enterprise, and to consolidate individual efforts in a common movement. The proprietors of the *Petit Journal* therefore organized a meeting of automobile vehicles, which took the form of a run between Paris and Rouen in 1894. The announcement of this competition created an extraordinary amount of interest, and upwards of a hundred cars were entered for the contest. Only some twenty, however, ultimately presented themselves for the trial, fourteen of which were driven by petrol engines, the remainder being

steam cars, but it must be remembered that at this period the steam engine had advanced much farther in efficiency than the petrol engine. De Dion and Serpollet, to mention only two of those who had been working at steam engines, had achieved very satisfactory results with light boilers generating high-pressure steam and very small engines.

Serpollet's great invention was his boiler, the principle of which was that instead of storing both water and steam, it generated steam instantaneously as it was required, by means of flattened tubes of a very narrow section which were kept at a red heat by the furnace, and through which the water was pumped and "flashed" into steam. At the Paris-Rouen contest the fastest performance was that of the de Dion Bouton steam carriage, which covered the distance, some seventy-eight miles, at an average speed of about twelve miles an hour. Almost all the other carriages, with the exception of those of le Blanc, who used the Serpollet generator, and Scotte, whose vehicle was an omnibus driven by a simple two-cylinder engine supplied with steam, were driven by Daimler motors, Messrs. Panhard and Peugeot dividing the first prize between them. This historic meeting opened up so many possibilities that it was decided to attempt a more complete organization of the movement, and towards the end of 1894 it was resolved that there should be a great road race from Paris to Bordeaux and back, a distance of 730 miles. This was an ex-

tremely severe test, as it was required by the rules that the journey should be performed in one trip, and that no repairs or replacements other than those possible by such tools as could be carried on the cars themselves would be permitted. In spite of the severity of the trial, about nine cars triumphantly endured it, and arrived safely back in Paris out of the twenty-two that started. The best performance was that of Monsieur Levassor on a Panhard car, who accomplished the journey in forty-eight hours and forty-eight minutes, having only stopped five minutes at Bordeaux.

The car upon which this historic feat was performed was built especially for the race by Messrs. Panhard & Levassor. It was driven by a 4 h.p. Daimler engine, had three speeds, the first of which was eighteen and a half miles an hour, and its wheels were fitted with solid rubber tyres. Three vehicles built by Messrs. Peugeot came in very soon after Messrs. Levassor's, and after that came two Roger's, and two more Panhard's. Steam was only represented by a large omnibus built by Bollée, which carried eight persons throughout the trip. Serpollet had entered a car, which, however, failed to complete the journey through a serious breakdown, a fate which was shared by the de Dion cars. This contest saw the first appearance of pneumatic tyres in long-distance automobile races, one of the competing but unsuccessful vehicles being fitted with Michelin tyres.

The committee which had organized this classic

race some months later look a further step towards organization by forming itself into a permanent commission, which in its turn gave birth to that famous body, the Automobile Club of France.

The contemplation of such successes in France could not leave public spirit in England entirely apathetic, though it must be remembered that at this time the law insisted that all motor vehicles should be preceded by a man carrying a red flag. In 1895 the Hon. Evelyn Ellis, who had been using the 4 h.p. Panhard car in France, brought it over to England, and Sir David Salomons a little later imported a Peugeot car. In October 1895 the latter gentleman invited several Members of Parliament and other people of influence and importance to a demonstration of motor vehicles at Tunbridge Wells. This was the first motor show in England, and consisted of Mr. Ellis' Panhard car, Sir David Salomons' Peugeot, and a de Dion steam car and a petrol bicycle. To Sir David and Mr. Evelyn Ellis belongs therefore the chief credit for the introduction of the modern motor-car into England. Their efforts to convince people of the future that lay in self-propelled vehicles were crowned with success when the President of the Local Government Board brought in a Bill to amend the existing law. Unfortunately a change of Government immediately followed, and the matter was dropped until the next year, when Mr. Henry Chaplin brought forward the Light Locomotives Act.

On November 13, 1896, this Act became law, and the day was celebrated by a run from London to Brighton, in which about twenty cars took part. About a year previously *The Autocar* had been founded, and had just given the new movement its place in the English Press. The Daimler Motor Company was formed in February 1896, and a year later they had made and sold their first carriage. Thus the new era of road locomotion dawned in England; but many valuable years had been lost, and British engineers began their conflict in the motor-car history with heavy handicaps. These in course of time they have been able to make up by a determination to follow lines of originality, and to leave no stone unturned on the road to perfection, for at the present date the British car justly ranks as the very finest in the world.

To us who see motor vehicles in great numbers every day working with efficiency, reliability, and silence, and operating upon principles which are almost obvious in their simplicity, it seems a great surprise that so many years should have elapsed between Trevithick's first practical steam carriage and the modern touring car. The way of the pioneer was, however, strewn with innumerable difficulties, and only those who took an interest in automobilism in the early days can appreciate the value of the efforts which were made to overcome them. The development of the motor-car was (it must always be remembered) enor-

mously accelerated by the introduction of the pneumatic tyre, which had been invented in 1885 by Mr. J. B. Dunlop, and primarily applied to pedal bicycles. The great increase of comfort which this tyre made possible, together with the enormous saving in wear and tear which it effected by insulating the working mechanism of the car from the principal road shocks, made it possible to run cars at a much higher speed than had formerly been possible with iron or wooden tyres. Even with the solid rubber tyres, which were used on the earlier cars, the vibrations set up by bad road surfaces were sufficiently severe to bring the career of these vehicles to a very early close, and the science of metallurgy, especially in regard to steel, being then in its infancy, it was not possible for engineers to obtain metals of sufficient strength to resist the strain imposed upon them in motor-car practice.

What the motor-car will develop into in course of time it would be difficult, or at least unwise, to predict. Very great strides in efficiency have been made, so that the amount of work which can be got out of a unit volume of cylinder capacity is to-day very considerable; though in the present state of the art something like 85 per cent of the available energy is wasted. It is possible that, in order to avoid this serious and needless expenditure of power, use may be made of electric accumulators, providing they can be made light enough to store a charge sufficient to

carry a car without a stop for replenishment over such distances as we have become accustomed to. Such an electric accumulator has, however, not yet made its appearance, although it has long been coming. If and when it does come it will, of course, have the advantage that it can be served with power at a central station, where, the engines and dynamos being large and weight being no consideration, a much higher efficiency and economy in fuel consumption can be effected.

CHAPTER II

INDUSTRY AND SPORT

The difficulties of the beginners—Automobile clubs—Brooklands—Racing—The growth of the industry—Motor-cycles and cycle cars—American competition

THE early days of automobilism present a picture of enthusiasm and a bond of interest between the seller of an article and its user that has never been equalled in any other industry. Whilst it was perfectly well recognized by any one who could summon the least imagination that the era of the motor-car would enlarge indefinitely, and that its use would extend to every conceivable aspect of business and pleasure in which locomotion is required, being unreliable and expensive motor-cars could at that time offer no advantages for use in any but sporting purposes. Indeed, to drive a car at all was something of an achievement, and compelled the admiration of those who knew what strenuous incidents had to be lived through to bring a run of any distance to a successful conclusion. Many of the best makes, even in the hands of intelligent drivers, did little but continually break down,

owing to defects in small details, which the progress of fifteen years has only just been sufficient to sweep away. Tyres were also a tremendous source of trouble, as the manufacturers had not yet learnt how to make covers which would stand up to the extremely hard work which the motor-car tyre of the early days was called upon to withstand. Little was known, for instance, about the correct pressures of inflation, and there is not the slightest doubt that many thousands of tyres were ruined before their time by sheer ignorance, not only on the part of those who had to deal with them, but those who made them. To be a motorist at all, or even to have ridden in a motor-car, was to have acquired some claim to an adventuresome career, for the earlier types were by no means free from danger; and in the light of later knowledge we know now that many of those who rode in them had little more than a fraction of an inch between themselves and a horrid catastrophe. Unfortunately, this was not always the case, for that factor of safety was not always there, and many deplorable fatalities occurred. That they did not stop the tide of enthusiasm, or retard the progress of the motor movement in the slightest degree, only proved that its inevitable possibilities had caught the imagination of the public, and in answer to their demand manufacturers strove harder and yet harder to eliminate the weak points from their productions.

The bond of union between all motorists, like that which exists between people who have suffered pain and privation together, was in consequence an exceedingly strong one, and it was not long before automobile clubs began to spring up in various parts of Great Britain. There can be no question as to the value of the services rendered to the motor industry, as well as to the pastime, by the Royal Automobile Club. Starting its life as the Motorists' Club in 1894, and consisting of a mere handful of enthusiasts who met in a room at Whitehall Court, and spent much of their spare time in hard pioneer work, it was afterwards named The Automobile Club of Great Britain and Ireland, and performed a great volume of useful work by promoting races and reliability trials, which together accelerated in a noteworthy degree the development of the more perfect car, by finding out the deplorable weaknesses of the existing models. It also sought to affiliate the various motor organizations which were springing up in the provinces, so that the whole might work towards a common interest and with a single impulse. Later on it received royal patronage, and the permission to call itself The Royal Automobile Club, and forsaking its old quarters in Piccadilly it built for itself the largest, most palatial, and most luxurious premises of any club in the world. Its house in Pall Mall represents worthily the dignity to which the motor industry has attained.

The Club had an extremely difficult task in

reconciling the interests of the trade and of private users, and on the whole it performed it admirably. It must be remembered in this connection that the Automobile Club was quite unprecedented in the circumstances in which it came into being. It could not possibly merely content itself with dealing with amateur sport, and hold itself aloof from trade interests, for members of the industry were, if anything, the most enthusiastic sportsmen, whose services and support could not be done without. Nor would it have been right if the Club had been entirely sporting, for automobilism is not, and never will be, comparable with such a thing as horse-racing, for the industrial issues involved in it are too great, and its practical bearing upon everyday life too important, for it to be governed by a group of men whose chief interest in it is that of sportsmen. Whilst it must be admitted that too great praise cannot be given to the R.A.C. for the good work that it has done in the past, it must be, and is, objected that the enormous influence it is capable of wielding to-day is not taken the fullest advantage of. The anomalous state of the law as it at present stands in relation to motor-cars bears very heavily upon private motor users, who are already very severely taxed. In seeking to expand itself and become a social institution, the Club has necessarily lost sight of some of the main objects for which it was initially formed, and it is to be hoped, therefore, that when it has accustomed itself to its high position of importance and wealth,

it will realize that much hard work yet remains to be done, and will not fail to make the wants of the motoring public known through the many mouthpieces of the Members of Parliament who are amongst its members.

The Society of Motor Manufacturers and Traders, which was early formed to protect the interests of the manufacturer of cars, does not directly concern the private user, except that as a consolidation and organization of industrial thought it has its influence on everything connected with motoring. The S.M.M.T. makes it its chief public business to organize the annual motor shows which have become an item of such great importance in the social calendar of the Englishman. By this means it has acquired an enormous amount of wealth, whilst as it represents practically every one concerned in the making of motor-cars and their accessories, its power is immense, so much so indeed that a mere word from its Council is sufficient, if necessary, to ban beyond hope of redemption any sporting or competitive motor event not rigidly limited to a private owner.

The Motor Union and Automobile Association, which commenced their career as separate bodies, and afterwards united to form a powerful institution, have done much to earn the thanks of motorists the world over, but especially in the British Isles, where their enterprise has certainly led to a great many reforms being carried out. The original object of the Automobile Association

was to provide a check against the police trap, which was, and still is, one of the greatest evils under which the private motorist has to suffer. It instituted a system of patrols by means of which motorists were warned of the presence of "measured distances." This object was eventually proved illegal, and the interest and enterprise of the Association has since been directed into more useful channels.

The amount of good which has been done to the British motor industry by the Brooklands Automobile Racing Club it would indeed be difficult to over-estimate. Having at hand a huge track upon which cars can be driven at any speed up to 140 miles an hour, the British manufacturer has not been so hampered by repressive legislation as he would have been had he been forced to test his racing cars on the road. But this is not all. The fact of the Brooklands track being in existence, and the regular contests which are held there about six times a year, have induced many car constructors to go in for racing who otherwise would never have regarded it as a practical and inexpensive means of improving the breed. It might be thought that track work, such as Brooklands permits, would not be so searching nor so certain to find out the weaknesses of design as road work; but actually the very reverse is the case, for the track is very far from smooth, and experienced drivers all agree in stating that the strains and stresses which it imposes upon a car are even

worse than those which would be met with on the road. The headway which British motor design has thus been able to make has enabled it more than to make up the distance at which in earlier time it lagged behind the Continent, and that this has very well been appreciated by the French motor industry is shown by the deliberate and thorough manner in which it has set about the revival of road racing.

It is not here necessary to dilate upon the merits or demerits of racing as a factor in the development of car design. It may, however, be pointed out that high-speed work has proved, and still proves, the royal road towards progress in car construction. It encourages the metallurgical engineer to produce material, the need for which would otherwise not arise, and it forces manufacturers to deal in a strictly scientific way with problems that in the ordinary course of events might be tackled by rule-of-thumb methods. In short, the Brooklands track has done more to counteract the disadvantages under which early English motor designers worked than anything else.

The enormous growth of the motor industry, and the vast volume of technical ability which became devoted to it, led to the formation in 1906 of the Incorporated Institute of Automobile Engineers, which is now a flourishing concern, and by means of its periodic papers and discussions is doing extremely valuable work. This body is, of course, a learned society only, and has little or no direct

importance from the public's point of view. On the other hand it represents perhaps the highest authority to which any problem can be brought, and may be looked to to deal with the insistent and vital fuel problem in that thorough and foresighted manner which has characterized its proceedings in the past. As such, the Institute of Automobile Engineers is a very real force, from the application of which the motor public can gain great advantages.

Although not strictly having anything to do with motor-cars, the Auto Cycle Union, which is a body affiliated to the Royal Automobile Club, merits attention inasmuch as it had to deal with and legislate for the early impulses which crystallized into the modern light car movement. During the season of 1912 considerable attention was drawn to the possibilities of achieving a poor man's motor-car by means of combining motor-cycle and motor-car design. The resulting vehicles were known as "cycle cars." A little thought will show that this movement was inclined to be a retrograde one, for it merely attempted to solve in a new manner problems which had been faced by early designers, and whose solution was represented by the full-sized car as we know it to-day. The cycle car movement showed, however, that manufacturers were alive to the enormous demand which existed for a cheap motor-car, which should be no less economical in running expenses than in first cost, and with this realization came the birth of the light

car industry, which has attained such proportions that already it boasts two journals of its own, and may be almost said to have acquired an independence of its own.

In the pages which are devoted to dealing with motor-car design, the claims of the light car have not been forgotten. It will be remembered that twelve to fifteen years ago many of the manufacturers who now make large cars were then making small ones, and the question may be asked: "Why, if the small car has inevitably developed into the big one, can one prophesy any stability for the miniature car of to-day?" The answer is simply that strenuous competitions and racing have shown that it is possible to produce material with which a miniature car can be made thoroughly successful. It is, of course, subject to strict limitations, but it is able, none the less, to conform to public requirements in point of comfort, reliability, and speed. The influence of American competition must not for a moment be lost sight of, and had this not existed, it is more than probable, indeed it is certain, that the light car movement would have lacked the necessary impetus to put it into motion, and so attract the attention of the European manufacturer.

CHAPTER III

THE PETROL MOTOR AND ITS CONNECTIONS

Section I. The fundamental working principle of the engine described
II. The multi-cylinder engine and its advantages
III. The balancing of an engine and its effect on the car
IV. Periodic vibration and what it means
V. The cooling system: The radiator—The fan—Pump circulation—Thermo-syphon
VI. Ignition: The magneto—The coil and accumulator
VII. Carburation: Elementary principles—The typical carburettor—The Smith—Zenith—S.U.—White and Poppe—The extra air valve
VIII. Lubrication: Various typical systems described
IX. The clutch: The need for a clutch. Various types: Leather—Metal—Multiple disc—Expanding, etc.
X. The gear box and its functions: The principle on which it works and its method of operation—The epicyclic gear
XI. Transmission: Chain, bevel, and worm drives—The Differential
XII. Brakes: Fundamental desiderata—Various types—The counter-shaft brake—The hub brake—Front wheel brakes
XIII. Suspension: A variety of types—The function of the springs—How they are generally arranged
XIV. Control: How the speed, the acceleration, and the pulling up of a car are effected
XV. Steering: The usually adopted mechanism described and its principle made clear
XVI. Electric transmission: Its advantages, disadvantages, and possibilities
XVII. Sleeve valve engines: How they differ from the type already described and their advantages
XVIII. Electric lighting dynamos: Working principles and variety of types described
XIX. Self-starters: How these labour-saving appliances work

SECTION I.—THE FUNDAMENTAL WORKING PRINCIPLE OF THE ENGINE DESCRIBED

ONE great and lasting result of the spread of automobilism is the higher standard in technical education which, whether he knows it or not, the average man of to-day possesses. The natural curiosity which one cannot but feel in regard to the working principle of vehicles which pass one, and in which one rides, day by day, has encouraged the most unmechanically minded to familiarize themselves with the petrol engine. Even so, however, the average man has but a hazy idea upon the methods by which the chemical energy stored in liquid motor spirit is converted into mechanical or kinetic energy at the road wheels. No apology therefore is required for commencing one's study of the construction and design of typical motor vehicles by devoting a chapter to an explanation of the why and wherefore of the principal components of the car. The accompanying diagrams must not be taken as illustrating the typical engine design of to-day. They are intended simply and solely to illustrate the working of a petrol motor. Modifications are required by considerations of design, but in essentials the petrol motor always remains the same.

For instance, the diagrams show a single-cylinder engine, which may be practically said to be non-

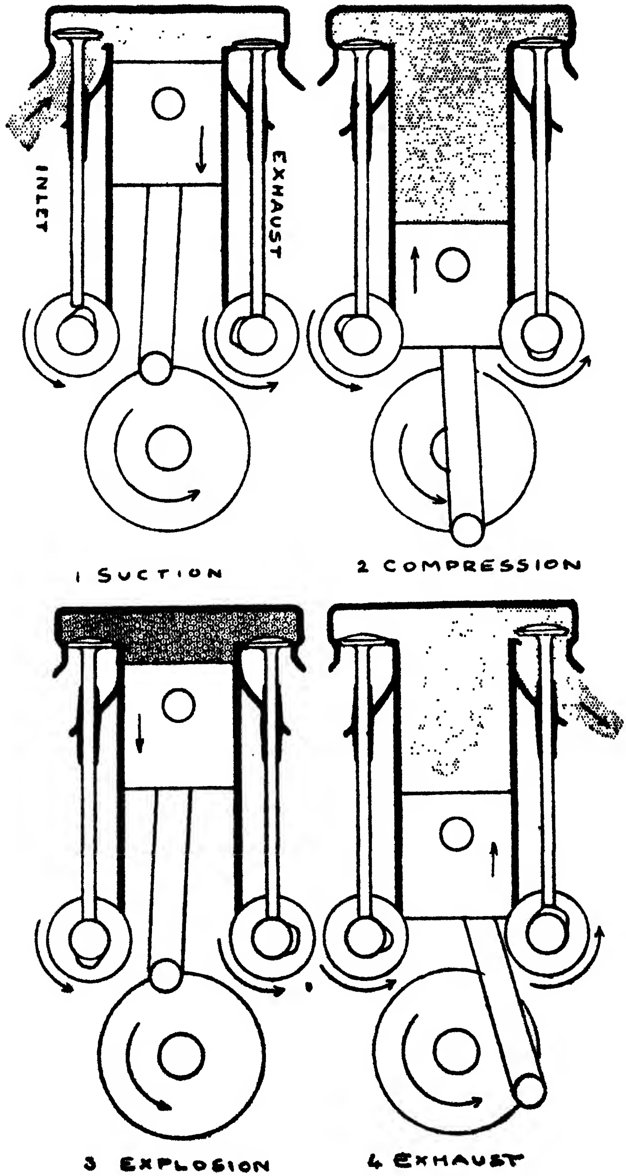

INLET
EXHAUST
1 SUCTION
2 COMPRESSION
3 EXPLOSION
4 EXHAUST

FIG. 1.

existent to-day as far as cars are concerned. The four-cylinder motor is, however, but a modification of the single-cylinder type, and the principles upon which it works remain unchanged.

Further, as will be shown later, other types of valve mechanism may be and are employed, but their functions are still the same in regard to the cycle of operations, and to understand therefore one form of engine is practically to understand all.

The type of petrol engine used on modern motor-cars consists, in its simplest form, of a cylinder closed at the top and open at the bottom, within which a closely fitting piston is adapted to move up and down, and to communicate this linear motion to a rotating shaft by means of a connecting rod and crank. The motive power is derived from a mixture of air with the vapour given off by petroleum spirit. This mixture is introduced into the cylinder itself, and when the piston is at the top of the cylinder is compressed between the fixed cylinder head and the movable piston. The gas is then ignited, and by the heat thus instantaneously generated is enormously expanded, forming, in fact, an explosion. As the piston is the only thing that can give way, the cylinder walls and head being made strong enough to resist the force of the explosion, it is forcibly driven to the bottom of the cylinder, where its further downward movement is arrested by the crank. As the piston must be gas-tight, it is first made a free sliding fit in the cylinder. Three or four parallel grooves are then

cut in its circumference, and into these grooves are sprung cast-iron rings, the circumference of which is slightly larger than that of the cylinder and very slightly eccentric to it, so that the natural spring of the metal causes them to bear closely against the internal walls of the cylinder and prevent any escape of gas. The impulse of the explosive stroke is stored in a flywheel attached to the crank shaft, and the momentum thus imparted to the shaft causes it to reciprocate the piston up and down the cylinder. A repetition of these movements thus constitutes a source of mechanical energy, and it will be seen that when the crank shaft makes one revolution, the piston performs two strokes, one up and one down.

In the Otto cycle of operations, which is employed in all motor-car engines, there is only one explosion to four strokes of the engine, the energy stored in the flywheel serving to carry on the work during the idle strokes.

The four strokes are termed respectively—The Suction Stroke, the Compression Stroke, the Explosion Stroke, and the Exhaust Stroke. To describe them properly in detail we must suppose the engine to be running.

1. *The Suction Stroke.*—The piston is at the top of the cylinder, and the combustion chamber, as the space between the top of the cylinder and the piston is called, is empty of gas. As the flywheel revolves it begins to pull the piston down, and a partial vacuum is thus created in the

combustion chamber. This chamber has two valves opening into it, the inlet valve and the exhaust valve, both being mechanically operated by means of cams mounted on a shaft, which runs at half the speed of the crank shaft. As the piston travels down the cylinder, the inlet valve is forced from its seat by the cam, and opens so that the suction caused by the downward moving piston introduces a supply of combustible mixture, which is drawn from the carburettor in a manner which will be described later. At the end of the suction stroke the piston is at the bottom of the cylinder, and the latter is entirely filled with gas.

2. *The Compression Stroke.*—The piston being at the bottom of its stroke, and the cylinder filled with gas, the travel of the flywheel carrying the crank round begins to thrust the piston up again. The moment it begins to do so, the rotation of the inlet valve cam causes this valve to close, so that the gas is hermetically imprisoned in the cylinder. As the piston rises it therefore compresses the gas, which has no means of escape, and by the time it has reached the top the combustion chamber is filled with inflammable mixture in a high state of compression, a state which is necessary if the proper explosive force is to be derived from its ignition.

3. *The Explosion Stroke.*—When the piston is at the top of its stroke the mixture is ignited by an electric spark, and its expansion or explosion drives down the piston with great force. This

energy being stored in the flywheel thus furnishes power enough for the three strokes in which there is no impulse, as well as for the purpose of driving the car. The piston is now once more at the bottom of its stroke.

4. *The Exhaust Stroke.* — As the flywheel, refreshed by the impulse imparted to it by the explosion stroke, thrusts the piston up again, the exhaust valve is opened by its mechanically operated cam, and this allows the burnt gas to be driven by the ascending piston out of the cylinder. As the piston reaches the top of the stroke, the exhaust valve is closed, and the cycle of operations begins with the suction stroke again.

The accompanying illustrations show the complete cycle in its four principal positions, and from these it will be seen that an explosion occurs with a single cylinder once in every two revolutions of the crank shaft. It will be realized that this being so, the use of a single-cylinder engine would result in the power impulse being given very intermittently, and to overcome this defect a multiplication of cylinders is necessary to get a regular torque or twisting effort at the crank shaft; two cylinders giving one power impulse for every revolution; four cylinders two power impulses for every revolution; six cylinders three impulses, and eight cylinders four. In practice the four-cylinder engine has been found to effect the cheapest and simplest compromise, and this is therefore the prevailing type, though for cars

in which luxury is intended to be an essential characteristic the six-cylinder engine is nearly always used, whilst the eight-cylinder engine is coming into popularity.

As will be seen from photographs which represent typical cars in a later chapter, the cylinders are arranged side by side, so that their construction in single unit masses of metal is much facilitated, and a single crank shaft with a number of crank throws, dependent upon the number of cylinders used, can be employed.

Section II.—The Multi-cylinder Engine and its Advantages

In order to illustrate the advisability of employing a multi-cylinder engine, what is called a torque diagram is given herewith, and shows what takes place in engines of various kinds during two complete revolutions of the crank shaft. In order to explain this torque diagram, it is only necessary to say that the height of any point in the curve above the horizontal line represents graphically the turning effort which is being transmitted to the crank shaft at that particular moment; and in order to make this more clear, the horizontal base line is marked off in divisions. Similarly, if the curve descends below the horizontal line it indicates the amount of work which is being returned to the crank shaft, which during this period is idle, and is receiving the necessary energy for rotation from

that which is stored up in the flywheel and in the momentum of the car.

The line marked A represents the torque of a single-cylinder engine, and the first stroke is the power stroke. Immediately after ignition of the charge, the torque becomes very high, reaching its maximum when the piston is in the mid-point of its stroke. It gradually falls off, and becomes nothing at all at the end of the stroke. During the next three strokes no positive work is done on the piston at all, and therefore the curve lies below the horizontal line, to return above it as soon as the explosion stroke occurs again. Briefly described, it will then be seen that the single-cylinder engine is very much of a "dot and carry one" arrangement, as the impulses only occur at intervals fairly wide apart.

The curve B is for a two-cylinder engine, which is now a rapidly obsolescent type, although scores of such motors are running perfectly satisfactorily. The particular type illustrated in the curve has its cranks set at 180 degrees, so that the piston explosions occur at unequal intervals; but there is as a matter of fact a second type of two-cylinder engine in which the crank shaft is differently arranged, so that the explosions occur at regular intervals. The torque of this last is traced in curve C. It will be seen that one line is less jerky and irregular than the other, and that the second type is certainly better from the point of view of constancy of torque. On the other hand the balance of the engine, that

is to say the reaction which is felt by the car, is very much worse. Here it will be seen that the

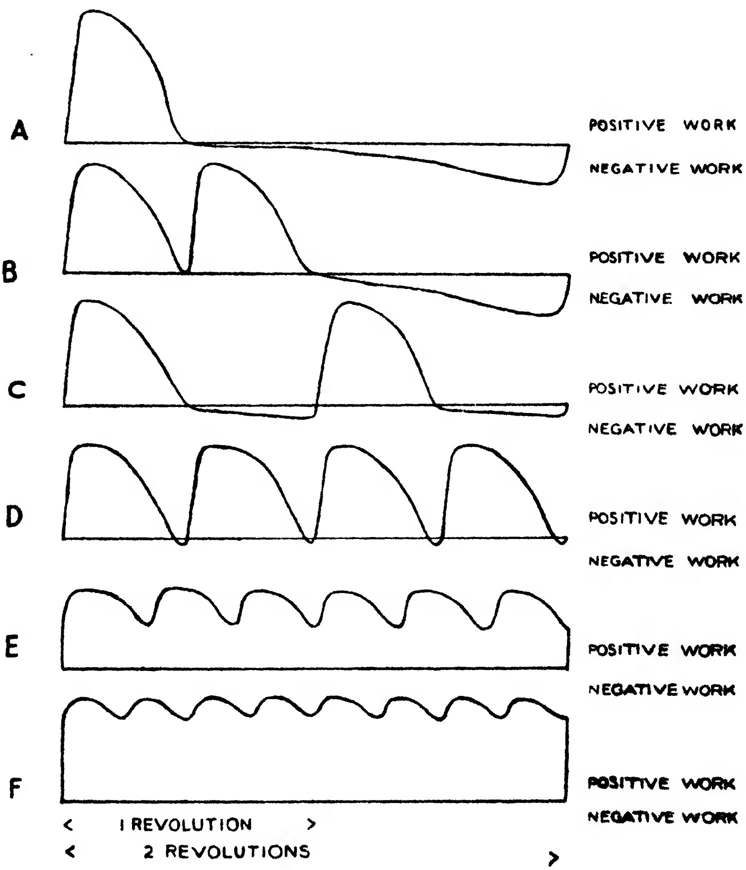


FIG. 2.

greater proportion of the torque line lies above the horizontal line, though in both cases it dips below it for short periods.

D is the torque of a four-cylinder engine, and since the impulses come four times as quickly as in the single cylinder, the line is more regular in form; that is to say, the vertical height between the peaks and the valleys is not so great. It simply means that the impulses are more constant and less noticeable. Even with a four-cylinder engine, however, a certain amount of negative work is done on the crank shaft, but it is only momentarily that the line dips below the horizontal.

The addition of two more cylinders, making a six-cylinder engine, creates a very great difference, as shown in the line E. Here the torque, it will be seen, is always positive—that is to say, there is always one cylinder in the act of propelling the piston downwards with the explosive charge. The flywheel therefore does no negative work, and the peaks and valleys are very considerably levelled.

A stage further is shown in F, which represents the diagram of an eight-cylinder motor, a type which is considerably used for aeroplane work, and promises to become quite popular for car work, though perhaps not in the immediate future. This engine gives a torque diagram, which can be described as not far off the straight line, as its impulses follow one another so rapidly, there being four to each crank shaft revolution. The ideal engine would give a straight line as a torque diagram—a result, however, which is only attained at the present state of our knowledge with a steam turbine and an electric motor.

SECTION III.—THE BALANCING OF AN ENGINE AND ITS EFFECT ON THE CAR

The subject of engine balancing is a matter of the utmost importance, but as its full understanding involves a considerable knowledge of mathematics, and to be properly treated would require a larger portion of this book than could be spared for the purpose, it is not proposed to go into it deeply, but rather to outline the principal causes which lead to vibration.

First of all it needs to be pointed out (for though a truth, it is not by any means obvious) that with a petrol engine, no matter how it is supported, there is always just as much tendency for the whole engine to turn itself around the crank shaft as there is for the crank shaft to turn round in relation to the engine; just as when a gun is fired, the same explosion that propels the bullet forward kicks the gun itself backward. This action and re-action are essentially equal and opposite. When an engine is driving a car along, the resistance imposed by the load causes every explosion to react upon the frame, according to the manner, whether lengthways or thwartways, that the motor is supported upon it. Reference to the torque diagram just spoken of immediately shows which type of engine will give the greater comfort by shaking the frame least, and it is for this reason that the single- and two-cylinder engines are now no longer cultivated, though

as a matter of fact the two-cylinder type can, in its horizontally opposed form, as used in the Douglas motor bicycle, be practically perfectly balanced, though it still tends to rotate about the crank shaft. Provided this rotational tendency is steady, it has no effect upon the comfort of the passengers; it is only when it is jerky that it is felt.

We are all familiar with the long spring-board which is used in swimming-baths for the purpose of getting a take-off for a running "header." Supposing we stand on the free end of such a board with a 7 lb. weight in either hand, then if we move these weights up and down fairly rapidly we shall find that the motion reacts upon the board, which also moves up and down; and if there were several people standing on the board behind us this motion would still take place, and we could, if we were able to move the weights quickly enough up and down, subject them to considerable discomfort, just as much as a person can by taking another by the shoulders and shaking him. This discomfort is primarily caused by the fact that the centre of gravity of the person moving the weights up and down is not in the same place continually, but is first in one position and then in another, according to the situation of the weights at any particular moment. If the person on the end of the spring-board were joined by another person, who stood immediately behind him with similar weights and operated them at the same speed, but moved them up when the first person moved them down, and

vice versa, the other people standing on the board would undergo no discomfort at all, because the centre of gravity of the two persons with their oppositely moving weights would remain in the same place.

This is a rough-and-ready analogy of what takes place in an engine. Supposing we have a single-cylinder motor, then the up-and-down movement of the weight of the piston causes vibration, and as the reciprocations occur very rapidly, anything up to three thousand or more times per minute at full speed, they are capable of being felt in the heaviest car, and cannot possibly be damped out except by adding another cylinder to work in an exactly opposite manner to the first. This can be done to a certain extent by placing the two cylinders side by side and using a crank at 180 degrees, but as we have seen from the torque diagrams, this engine does not give a very satisfactory impulse effect, and moreover the degree of balance to be obtained in this way is not perfect, although it is, of course, much better than none at all.

There are two reasons for the engine being still unbalanced. The first is, that the first piston does not move up and down in the same plane as the first, so that the conditions are analogous to having a stick held by two people, one of whom pulls one end in one direction, whilst the other pulls the other end in the other direction. This forms what is known as a "couple," and tends to make the engine turn first in one direction and then in the

other about an axis running transverse to the plane of the pistons.

The second reason is, that unless the connecting rods are of infinite length, the first piston does not descend at the same proportional rate of travel as the second piston rises, and consequently, though it is only to a small extent, the centre of gravity of the moving parts still alters its position up and down.

The first of these objections can be got over by adding two more cylinders, thus making a four-cylinder engine; and by suitably arranging the cranks so that the pistons of the outside cylinders are travelling down, while the pistons of the inside cylinders are travelling up, the unbalanced couple above referred to disappears, for the conditions are analogous to four men holding a stick and pulling against one another, two seizing the middle and pulling in one direction, and the other two holding on one at each end and pulling in the other direction. With such an arrangement there is no tendency (providing the men be equally strong) for the stick to move at all in any direction. It is true that the lack of balance, due to the angularity of the connecting rod, still remains, but this is not of great relative importance, and this fact has resulted in the four-cylinder engine becoming enormously popular, as it gives the best result commensurate with the smallest number of cylinders, and at the same time is a type of motor particularly suitable for attachment to the frame of a car.

In the six-cylinder and eight-cylinder engines, something more than an amelioration of the torque effort is obtained, for the lack of balance, due to what is called the angularity of the connecting rods, is wiped out, so that to all intents and purposes no vibration is produced by these engines at all, providing they be properly designed in the first place.

Section IV.—Periodic Vibration and what it Means

With the six-cylinder engine it is often noticed that vibration does occur at certain speeds, disappearing when those speeds are either increased or decreased. This is known as "periodic vibration," and is due to the fact that the crank shaft for this type of engine is of considerable length. Let us suppose such a shaft to be mounted on bearings with a flywheel at one end, whilst at the other the shaft is firmly fixed so that it cannot turn. Then if we take the flywheel and give it a twist, we shall be able to do so against the natural spring of the shaft, and if we release the flywheel it will oscillate to and fro at a rate which is dependent upon the characteristic springiness of the shaft. When in like manner a piston transmits its power to the shaft, it tries to accelerate the flywheel, and the inertia of the latter causes the explosive force to tend to twist the shaft. Now if the engine is turned at a low speed, the springiness of the shaft will allow it to twist back

again immediately after the initial explosion has occurred, and the very small movement of the piston in the cylinder, which is due to this elasticity of the crank shaft, will not cause any perceptible vibration. If the engine is turning over fast, then the shaft will not have time to spring back, and at a certain speed the natural oscillations of the shaft will correspond to, or be a multiple of, the up-and-down reciprocations of the piston. This causes what is known as "periodic vibration," which can be cured either by using a shaft of extraordinary stiffness, so that the speeds at which vibration occur are so high that they will never be reached in ordinary use, or else by adopting a special form of vibration damper, which is fitted to one or two cars, and which will be described later.

It may be pointed out that periodic vibration also occurs in four-cylinder engines, but as in these the crank shafts are shorter, it is less marked, and can be more easily restrained.

We shall consider, before passing on to a description of several typical motor-cars, some of the other connections of the petrol engine.

Section V.—The Cooling System: The Radiator—The Fan—Pump Circulation—Thermo-syphon

Since the explosion of a mixture of petrol vapour and air produces intense heat, it is obvious that

the cylinder of an internal combustion engine must get extremely hot, and unless proper provision is made to cool it, it will be impossible to lubricate the working surfaces of the piston, whilst furthermore the temperature might become so high that the incoming gas would be automatically ignited by the red-hot cylinder walls, and would not wait to be inflamed by the ignition spark at the proper time. Moreover, on entering the hot cylinder the gas is immediately expanded, and therefore the hotter the cylinder is, the less weight of gas can be got inside it on the suction stroke, from which it follows that the less is the power of the explosion. In small engines, such as those which are used on motor-cycles, air cooling is satisfactory, and the cylinder can be maintained at a reasonable temperature by allowing it to radiate its heat direct to the atmosphere through a series of ribs or flanges, which largely increase the effective radiating surface of the cylinder interior. On a motor-cycle the engine is, of course, not covered with a bonnet, and is in a position to receive a perpetual blast of air so long as the machine is travelling along. If the engine had to be run with the machine stationary for considerable lengths of time, as is the case with cars, air cooling would no longer be effective, and thus on several motor-cycles water cooling on similar lines to that adopted on cars is employed, though the principal cause which leads to its adoption on the former is that the engines are larger in size and much

more powerful. Consequently the heat is very much greater, whilst the area of metal available for dissipating it is by no means proportionally increased. Water cooling provides an intermediate agent between the cylinder and the atmosphere, for the water which takes away the heat from the former is eventually cooled by the latter. The whole of the cylinder, especially its "head," where the temperature is greatest, and the valve ports, etc., are surrounded by a jacket, which is generally cast upon them in a single piece of metal, though in some cases it is formed of copper or some other metal and suitably attached to each separate cylinder. Through this water jacket a constant circulation of water is maintained, either by means of a pump of the centrifugal type, which is similar to a fan working in water and driven by the crank shaft, or else on the thermo-syphon principle. The radiator for cooling the water after it has passed through the engine, and which serves the purpose of preventing it boiling away, is an arrangement of tubes or water spaces, which allow the maximum area of cooling surface to be exposed to the air; and in order to ensure that a draught passes through them when the engine is standing still as well as when it is running, a rotary fan driven by the engine is placed behind it, or fan blades may be formed into the engine's flywheel to the same purpose.

To increase the effective area of the tubes what are known as "gills" are attached to them, or in

some cases what is known as the "honeycomb" principle of construction is adopted, in which the air passes through a system of horizontal tubes, whilst the water flows outside them. The thermo-syphon principle of water circulation depends on the fact that hot water being lighter than cold tends to rise. The same principle, of course, is made use of in hot-water heating of houses. In

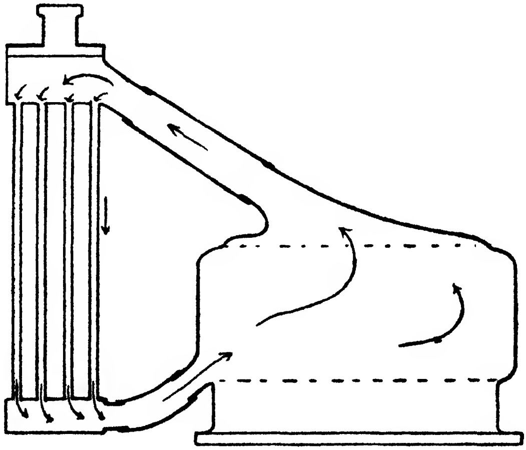


FIG. 3.

the case of a car, the engine itself supplies the place of the fire, and the hot water generated as indicated by the diagrammatic sketch ascends of its own accord through a large diameter outlet pipe, which, to accelerate its flow, is as sharply inclined as possible to the top of the radiator. This flow induces another flow from the bottom of the radiator to the base of the engine jacket through the water

inlet pipe. The hot water at the top of the radiator is cooled by the air, and flows downwards to the bottom, so that a constant circulation is maintained. In some cases, such as the Renault, Charron, and Arrol-Johnston cars, the radiator is not placed in front of the engine, but behind it on the front of the dash-board, as in this case a higher position of the radiator can be obtained, and the thermo-syphon flow is therefore more rapid, as the higher the cooling member is above the heating member the greater is the length of column of water, the motion of which is to be turned to advantage.

In many cars it has been found that to obtain a neat appearance the radiator in front of the engine could not be placed high enough, and therefore there has been a return to a pump circulation, which at one time the thermo-syphon threatened to supersede.

Section VI.—Ignition: The Magneto—The Coil and Accumulator

Without a spark to ignite the explosive mixture inside the cylinder the engine can give no power, and unless the explosions occur with perfect regularity, only jerkiness in running can result. It is essential, therefore, for the spark to be produced with perfect reliability, and the development of the ignition apparatus for motor-cars is a striking case of how a complicated and delicate mechanism can be almost perfectly specialized, and be made to

work so well that it requires practically no attention from one year's end to another.

In the early days of the internal combustion engine, tube ignition was employed, and consisted of a hollow stem screwed into the piston chamber and kept at a red heat by a stove burning the same fuel as the engine. The mixture on being forced into this narrow tube at the conclusion of the compression stoke was ignited. This crude arrangement was soon displaced by electric ignition, of which there are three distinct forms in common use to-day, namely (1) the magneto, (2) the trembler spark, (3) the jump spark.

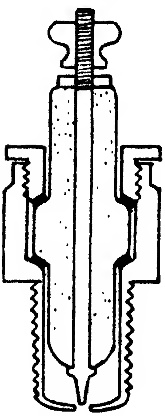


Fig. 4.

In order to effect clarity in the description, these types will be described in inverse order, but the description may be prefaced by the statement that all of these types use exactly the same form of sparking plug, and the construction of this component will now be briefly discussed.

It consists, as shown in the sectional sketch, of a metal body adapted to be screwed into the cylinder head, and containing an extension, which is curved round to form one of the sparking points. The other is the end of a central electrode, which is carried in a porcelain insulator, the whole being designed to withstand very great pressures without bursting or leakage. The other end of the central

electrode is connected to the source of high-tension current, whilst the other, being in metallic contact with the engine, is "earthed."

The jump spark is produced by a battery in conjunction with an induction coil. In the latter there is a primary winding connected to the battery, surrounded by a secondary winding of very fine wire, in which the current passing through the primary induces what is called a high-tension current, which is capable of leaping across a considerable gap. The high-tension spark is caused by breaking the flow of current through the primary winding, and the greater rapidity with which this break is made, the greater is the intensity of the spark. A cam, driven by the engine through a two to one gear, forms an alternate making and breaking effect, and produces, through suitable connections made between the coil and the sparking plug, ignition of the gas in the cylinder.

Trembler coil ignition works on an exactly similar principle, except that the making and breaking of the low-tension or primary current is effected by a vibrating armature, which works on a similar principle to the clapper of an electric bell, and is alternately attracted and released by the central core around which the primary circuit is wound. In this case the mechanism on the engine is required only to make the current connection, and not to break it suddenly, and therefore what is known as a "wipe" contact is employed, which, as it were, switches on the spark exactly when it is required

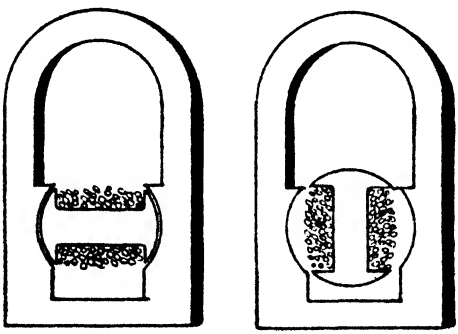
in the engine. Instead of a single spark occurring, rapid vibrations of the trembler cause a number to take place, so that the mixture is fired with greater certainty, although the trembler spark is not capable of allowing an engine to turn over at such a high speed as the other ignitions.

The high-tension magneto may be described, however, although the previous types of ignition still exist generally side by side with it, as the standard form of ignition for all internal combustion engines, and its introduction has probably done more than anything else to enhance the reliability of the motor-car and bring it to the position it now occupies of being a necessity even more than a luxury.

Briefly described, the high-tension magneto is an electric machine, which does away with the necessity of storing energy for ignition in batteries, as, like the dynamo, it generates its own current when driven by an engine. How the magneto works will not be described at length, but some conception of its principle may be obtained from the diagram, which shows its essential parts in section. It is practically up to a certain point a dynamo, in which the place of the electro-magnets is taken by permanent magnets, which are of the horseshoe shape and fitted with pole-pieces or cheeks, which partially surround an "H" section armature, which revolves between them on a spindle. This armature is wound from end to end with numerous coils, first of thick insulated copper wire and then of very fine

wire, the thick being the primary winding and the thin the secondary winding.

The power of generating electric current in the magneto depends upon the fact that when a coil of wire cuts the lines of force in a magnetic field, current is generated in this wire, and may be drawn off. In the first illustration the armature is shown in such a position that it does not cut any lines of force, as these can pass from one pole-shoe to the



(*a*) (*b*)

Fig. 5.

other through the soft iron body of the armature itself. If, however, the latter be moved to the position shown in the second illustration, the magnetic flow is interrupted and current generation takes place, first in one direction and then in the other, as the armature spindle is revolved. This current is generated in the primary winding, and induces a high-tension current in the secondary winding, this being carried to the plug and used for purposes of ignition. To induce a spark the

primary circuit has to be broken, and this is performed by a contact-breaker mounted on one end of the armature spindle, and consisting of a small rocking lever carrying a platinum point which is held against another platinum point until the other end of the lever strikes against a cam, which forces the two points rapidly apart. This causes the high-tension current to leap across the points of the plug in the form of a spark, and to return to the magneto body via the casing of the plug and the engine itself.

For single- and double-cylinder engines the magneto is caused to revolve at one-half the engine speed. On four-cylinder engines it revolves at crank-shaft speed, on a six-cylinder one and a half times crank-shaft speed, and on an eight-cylinder twice the crank-shaft speed, so as to provide the necessary number of sparks, and at the right times, as it gives two sparks for each revolution of the armature.

The time at which the spark occurs in the cylinder, that is to say in reference to the position of the piston on its explosion or compression strokes, is of the utmost importance upon the power output. At first glance it might seem as though the spark would have to occur either exactly at dead point, or immediately the piston commences to travel on its downward power stroke. But this is not actually the case, for the complete inflammation of the mixture takes an appreciable length of time, and it is therefore necessary to initiate this

inflammation, especially when the engine is turning at high speed, considerably before the piston reaches the top of the compression stroke. If an early timing of the spark be employed when the engine is running slowly, inflammation will have time to take place completely, or nearly completely, whilst the piston is still travelling upwards, so that what is known as "pre-ignition" will occur, and the engine will commence to knock, if not actually to stop.

In starting up an engine through the handle it is therefore necessary to see that the spark is not advanced, otherwise a broken wrist or a painful bruise is to be expected.

Since for high-speed running a different setting of the ignition timing is required to that advisable for low-speed work, a means for varying this timing is placed under the control of the driver, and in nearly all cars this takes the form of a lever mounted on the steering-wheel through which the position of the cam which operates the contact-breaker of the magneto can be moved forward or backward. Owing to the fact that the intensity of the spark produced by a magneto depends upon the number of lines of force which are cut by the armature when the low-tension circuit is broken, it follows that there can be only one position of the contact-breaker which gives the maximum effect, namely, that which breaks the current circuit when the armature is standing upright, as it were, between the poles of the magnets.

In practice most magnetos are generally arranged so that the most intense sparking occurs when the ignition is advanced, though in some cases (notably in the Mea magneto) an arrangement is made whereby whatever the position of the ignition lever, the spark is always at full intensity. In the cheaper forms of car it is common to find no ignition lever used at all, as of course its installation costs a certain amount of money, which cannot be afforded where price is of the utmost consideration. Fixed ignition, however, is quite satisfactory on small high-speed engines, and has the advantage of at least removing a complication in control; but it must be pointed out that fixed ignition, in conjunction with a magneto, is very much better than fixed ignition with a jump or trembler spark, for this reason, that as the engine turns faster, the magneto generates a greater pressure of current, and the greater this becomes, the quicker it overcomes the resistance of the windings and wiring, and the more rapidly does the spark at the plug follow upon the breaking of the low-tension circuit. To a very small extent, therefore, magneto ignition automatically advances itself.

In certain particular magnetos, notably the Eisemann, an arrangement is incorporated whereby a more complete automatic adjustment of the timing is effected. This consists of a centrifugal governor, which, as the engine speed increases, operates the advance ignition mechanism, and thus saves the driver from having to control this himself.

It does not, however, give quite as good results from the point of view of efficiency as a thoroughly experienced driver can get, owing to the fact that it does not take into consideration small variations which exist in engines which are outwardly exactly the same.

Section VII.—Carburation: Elementary Principles—The Typical Carburettor—The Smith—Zenith—S.U.—White and Poppe—The Extra Air Valve

The petrol engine differs in no essential from a gas engine as ordinarily used in workshops and factories, beyond the necessity which arises for furnishing it with a portable gas works. This is called the carburettor. As a great deal of individuality is expressed in different designs of this instrument, it is not possible to deal with them all. First of all the general principle will be explained, followed by a detailed description of a few popular types, and by brief descriptions of other designs.

In the early days of motoring, surface carburettors were used, and these were of the simplest possible type. They consisted simply of a tank of petrol, in which a tube communicating with the open air was run practically to the bottom of the liquid, whilst another tube above the level of the petrol was conducted to the inlet valve of the engine. The suction of the latter induced a flow of air to bubble through the petrol and get im-

pregnated with vapour, the amount of air being regulated by a hand lever, and the amount of mixture admitted to the engine by a throttle. The disadvantage of the surface carburettor was, that it was only efficient for slow and practically constant speed engines, and further, that it caused the petrol to be fractionated—that is to say, the more volatile constituents of the liquid were evaporated first, so that when the tank was nearly empty, the petrol left was considerably heavier and less easy to vaporize than the original supply.

Another type of carburettor, known as the Wick, enjoyed some extended use, but is now only incorporated in the Lanchester car. This Wick carburettor consists of a chamber, in which a series of wicks are arranged, past which air is drawn by the suction of the engine. This instrument gives very satisfactory results, but it is only in a specially designed car that space can be found for it.

The standard instrument on modern motor-cars is the Spray carburettor, which, in essentials, consists of two parts. One takes the form of a float chamber, in which a simple arrangement consisting of a float and a needle valve is employed to ensure that the level of petrol fed thereto from the tank is maintained at a constant height. This float chamber is in communication with a small jet, placed centrally in a constricted tube, connected with the inlet pipe. The suction of the engine induces a flow of petrol through the jet, which rises like a fountain, and is split up into fine

particles, and so caused to atomize or evaporate by the air rushing past it.

In the earlier types of Spray carburettor both the air and the throttle were separately controlled, but in the modern instrument the former is done automatically, although it is customary to find some provision of an air adjustment made, in order to

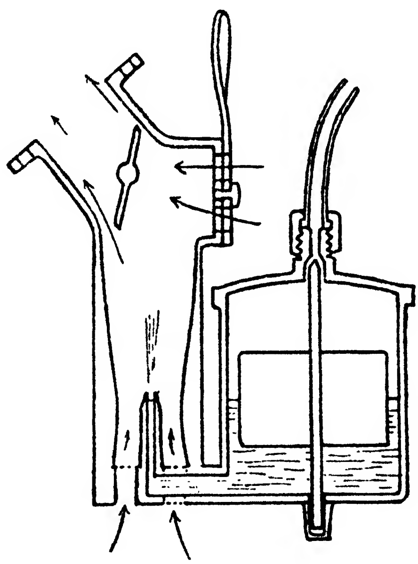


FIG. 6.

allow for changes in temperature. It is obvious that in hot weather the petrol evaporates more easily, and therefore a larger supply of air can be given. To overcome the necessity for readjustment to the greatest possible extent, it is customary artifically to heat the air supply by drawing it from a chamber surrounding the exhaust pipe.

In the Smith carburettor, which is a well-designed instrument of the "automatic" type, the float chamber supplies petrol to four different sized jets, each of which is contained in a choke tube, formed by dividing a tube into four compartments with a central web of **X**-section. Mounted on this tube, and adapted so as to be free to slide up and down it, is a cap which contains four holes communicating with the choke tubes of the jets. These holes are so arranged that when the cap is lifted by the suction of the engine the jets are opened up progressively. One of the jets is fitted into a very constricted tube, in order to provide a mixture suitable for running the engine at a very slow speed. For this purpose the air is caused to rush past the jet very rapidly, although only in a small quantity by means of the constriction. As the throttle is opened, the suction of the inner pipe becomes greater and greater, and the cap fitting over the jet tube is lifted to a higher degree, so that at first the engine runs on one jet, then on two, then on three, and when the throttle is fully open, on four. By this means perfect compensation and automaticity of working is obtained, or if not perfect, at all events the compromise is near enough to give very efficient working.

In the Zenith carburettor there are two jets, one of which is supplied direct from the float chamber, whilst the other is fed from a tubular reservoir, which is in turn supplied from the float chamber through an orifice, which is very accurately gauged

to pass a definite amount of petrol in a unit time. The idea is as follows:—

In the simplest kind of carburettor, which consists of a single tube placed in the inlet pipe, the inrushing air sucks a varying amount of petrol, according to the speed of the air past the jet, and the greater the speed the greater is the amount of petrol introduced. As a result, the higher the engine speed the more rich the mixture, which is by no means what is required, and which, as we have seen, has to be negatived by having a controllable air supply. In the Zenith carburettor the second jet is arranged to draw its supply in such a manner that the reverse action takes place; that is to say, the higher speed of the air past the jet, the less petrol does it take up.

Since these two actions oppose one another, the result is the formation of a constant mixture at all speeds.

The throttle valve consists of a diagram arranged diagonally across the inlet pipe, and adapted to be worked either by a pedal or a hand lever.

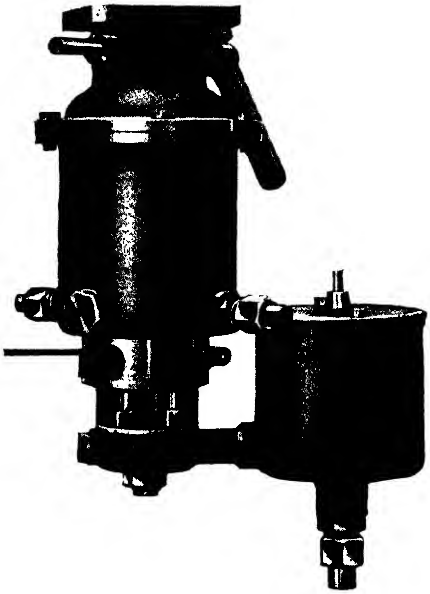
In the S.U. carburettor an ingenious method of obtaining automaticity is employed. This carburettor has a single jet, the orifice of which is varied by a tapered needle valve working in it axially, this valve being moved by the suction of the engine. The needle is attached to a metal plunger, which works up and down quite freely in a tube by means of a bellows connected to the inlet pipe. When the suction of the engine is low, or in

other words, when the engine speed is small, the plunger and the needle valve are held down on the jet, so that the latter is quite small, and the passage for the air to rush past the jet is small also. This makes the flow of air very rapid, so that a perfect atomization of the liquid is effected. When the suction is increased, the piston carrying the jet moves outwards and upwards, thus making the jet larger, and providing a wider space for the air to pass through. Thus, for any opening of the throttle, and for any load of the engine, the quality of the mixture remains to all intents and purposes constant, whilst by using slightly different-shaped needle valves the best consumption results can be obtained from any engine.

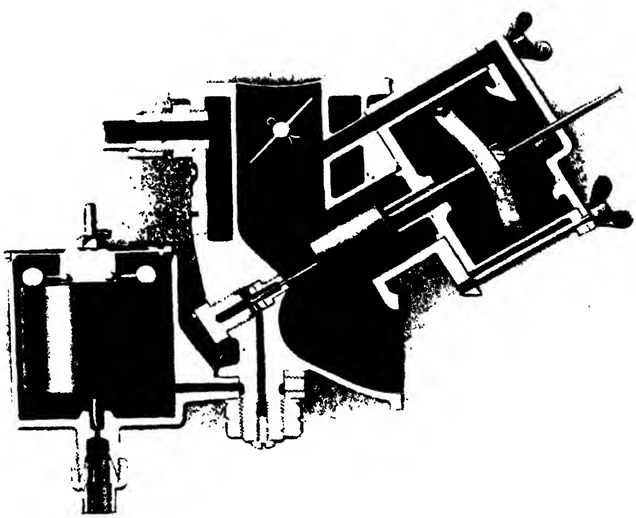
Another popular type of carburettor is the White and Poppe, which is designed upon very simple and effective lines. The principle upon which it works is as follows :—

When the throttle is open, the orifice of the jet is increased, and the air admission also opened. The latter can, however, be altered relative to the jet opening at any particular position, so as to suit changes in temperature and climate. The jet itself consists of a hole bored in the side of a cone, which works over another cone, in which a second hole is bored. The two are held together by a spring, and upon the throttle being opened the cones move on one another, and open or close the jet orifice.

Many motor manufacturers design their own carburettors, and use them exclusively, but it is



THE SMITH FOUR-JET AUTOMATIC CARBURETTOR



SECTION OF THE S.U. AUTOMATIC CARBURETTOR

more common to find them fitting those which are the work of specialists. In different cars the type of carburettor thus varies, but generally speaking they all work on much the same principle. One of the simplest instruments consists of a carburettor designed to give a richer mixture; that is to say, considerably richer than the engine would normally run on. Just before entering the inlet ports this rich mixture is weakened by the admission of air through an automatically operated valve, which can be adjusted by means of altering the tension of the spring. In order to prevent it working too quickly or suddenly, such a valve is generally provided with a dashpot or brake, which prevents it vibrating to and fro, though it does not affect its definite positive working.

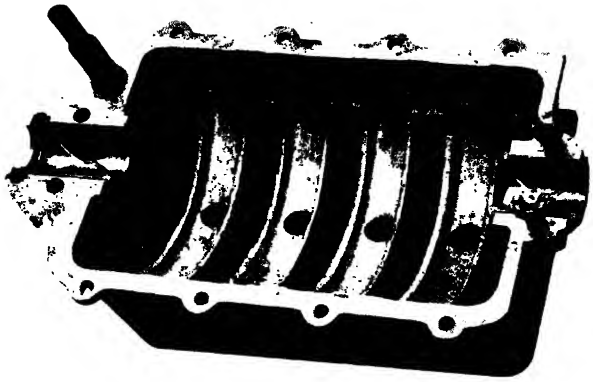
In order to reduce as far as possible the extent to which carburation is affected by changes in temperature, some method of artificial warming the mixture is nearly always adopted. This may be done in two ways; either the air supply may be drawn from a chamber surrounding the exhaust pipe, or the body of the carburettor or part of the inlet pipe may be fitted with a water jacket, which is interconnected with the cooling system of the cylinders, so that a constant flow of hot water is maintained around it. Both systems work equally well in practice, but of the two, the former method is perhaps the simpler. When this is employed it is desirable to have some form of regulator so that in hot weather the hot air supply can be temporarily

cut off, or at all events partially diluted with cold air. How ever well a carburettor works, it is generally found that the fitting of an extra air valve to the inlet pipe can improve the fuel economy obtainable. This valve is worked through a Bowden wire by means of a lever carried on the steering wheel, so that the driver can satisfy himself by trial exactly what dilution of the mixture best suits his engine. By this means the cylinder heads can be kept fairly free from excessive deposits of carbon, which are the result of bad or incomplete combustion.

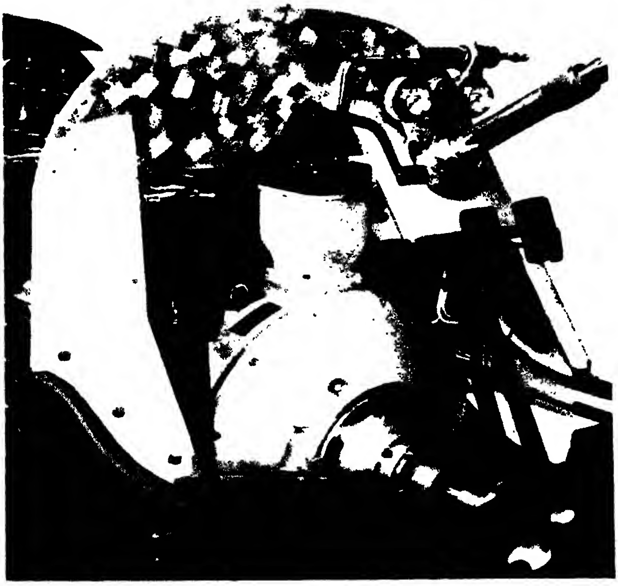
The extra air valve is also useful as forming a very soft and smooth working brake in descending long hills, as if it is open full the engine receives a supply of pure cold air, which it compresses, and then allows to expand. This offers a resistance, and thus the engine is made to work as a brake, which saves wear and tear on the mechanism of the chassis.

Section VIII.—Lubrication: Various Typical Systems Described

No component associated with the petrol engine is of more importance than the lubrication system, upon which the successful working of the motor very largely depends. It is not generally realized that between the surfaces of all working parts in the engine there must constantly exist a thin film of oil, and if the two pieces of metal actually came



OIL TROUGHS CAST INTO THE BOTTOM HALF OF A CRANK-CHAMBER FOR THE BIG-ENDS OF THE CONNECTING-RODS TO DIP INTO, AND WHENCE THEY SPLASH UP A SPRAY OF LUBRICANT



THE NEATLY-ENCLOSED ELECTRIC SELF-STARTER —FACING THE FLYWHEEL—OF THE SHEFFIELD SIMPLEX ENGINE

into contact through this film failing, excessive wear would take place, and the bearings would be completely ruined.

Several systems of lubrication have been devised, and all work satisfactorily where due care is taken in their design. The splash type of lubrication was used in early petrol motors, and owing to its simplicity it is still retained in many modern engines, though considerably improved in detail. In this system a pool of oil is maintained at a constant level in the crank chamber, and into this pool the big ends of the connecting rods dip at every revolution of the crank shaft. As the speed of these parts is very high, the oil is forcibly thrown up in the form of a spray, and falls upon all the working parts, being guided to the proper place by channels and grooves cut to conduct it. The oil supply is commonly contained in a vessel called a sump, which forms as it were a cellar below the crank chamber proper. From this it is drawn by some form of pump, and directed into the troughs under the big ends, maintaining them always full, so that however the engine is working, the big ends always dip to the same amount.

A very common system of lubrication, and one that is eminently satisfactory, is known as the "force-feed type," and was devised simultaneously by Lanchester and Maudslay. In this principle the oil is directly fed by a force pump to all the working parts. The supply is carried as before, in a sump beneath the crank chamber, and the

pump directs it through suitable channels to the main bearings upon which the crank shaft revolves. From here it is taken through the hollow crank shaft itself to the crank pins, where it lubricates the big ends of the connecting rods. It passes thence up the connecting rods, generally through small copper pipes attached thereto, to the little end or gudgeon pin, which it lubricates, the excess of oil from this point flowing on to the cylinder walls.

As it is impossible to make the big end bearings perfectly tight, a certain amount of oil under a pressure of anything up to 50 lb. per square inch leaks past them, and is flung on to the cam shaft, and also on to the cylinder walls, afterwards returning to the sump through a large filter, which removes all impurities. The oil consequently circulates time after time, but of course a certain amount is burnt up through getting past the cylinder, and periodical replenishment of the supply has to be made.

In a great many cars a cross between these two systems is employed; that is to say, the main bearings of the crank shaft are fed direct, and sometimes also the big ends, but splash is relied upon to lubricate the piston, cylinder walls, gudgeon pin, cam shaft, etc. In some cases a special feed of oil is directed to the thrust side of the cylinder wall. It will easily be understood that when the crank is at an angle, and the explosion is acting on the top of the piston, a considerable pressure

is developed between the piston and the cylinder wall on one side, and an extra supply of oil to this point is consequently desirable.

Great strides have been made in the efficiency of lubricating systems, and it is now quite common to find large cars running over a thousand miles on a single gallon of oil. In order that the driver may assure himself of the proper working of the lubrication, a pressure gauge or some other form of tell-tale is mounted on the dashboard, so as to show at a glance that everything is working satisfactorily. Should the pressure gauge go back to zero when the engine is running, it would indicate that the supply of oil to the pump had failed, and that immediate replenishment was necessary.

Section IX.—The Clutch: The Need for a Clutch. Various Types: Leather—Metal—Multiple Disc—Expanding, etc.

From what has been said already in describing the general arrangement of an explosion engine, it will be realized that unlike the steam engine this type of motor cannot overcome a load, that is to say, start a car from rest unless it is itself running, and so developing power. Accordingly some form of connection has to be made between the engine and the driving wheels, which can be thrown completely free to enable the engine to run independently, and which can also provide a

gentle and progressive engagement between the power and the load. This object is effected by the "clutch," which is found in several forms. The most common type is the leather to metal. It consists of a metal dish with sloping sides, similar in shape to a circular frying-pan. The sides are covered with a strip of leather, riveted securely in position. The whole fits into the fly-wheel, the inside of the rim of which is cut at a suitable angle exactly to fit the leather face, and the two are held together by a powerful spring. A pedal which is operated by the driver's left foot operates a mechanism, which withdraws the clutch from the flywheel, and so allows the engine to run free. As the clutch faces are allowed slowly to come together, the drive from the engine is taken up until when the clutch is completely "home" the engagement is perfectly positive, and both it and the flywheel revolve to all intents and purposes as one body. As a matter of fact, there is always a very slight amount of slipping taking place, and this is very useful because it does away with any harshness in the drive from the engine, and consequently increases the comfort of the passengers in the car, as well as tending towards economy in the tyres on the driving wheels.

It may be mentioned that the leather clutch dates back from the earliest days of the motor-car, and although it has frequently been condemned as unmechanical, and generally bad from

a theoretical point of view, in actual practice it works extremely well, that it is easily the most popular type to-day, and what is more has in many cases recently ousted other forms of clutch.

One of these is the multiple-disc type. Carried in the centre of the flywheel is a boss or sleeve, in which are cut a series of longitudinal grooves. On this sleeve are mounted a large number of thin metal discs, each having internally cut teeth or projections, which engage with the grooves on the sleeve, so that the discs revolve positively with the latter, though they are capable of sliding backwards and forwards upon it. Forming a housing round these discs, but not connected with them in any way, is a tube which is connected to the clutch shaft. In the inside of this tube are longitudinal grooves and a further number of discs, which again revolve positively with the tube, but can slide in and out of it.

These last discs are spaced alternately with the discs on the flywheel, and are normally pressed tightly together by a spring. In this case they give a perfectly positive drive, as they form a frictional connection between the outer tube on the clutch shaft and the flywheel. Pressing the clutch pedal down relieves the pressure on the spring and the discs immediately come slightly apart, thus allowing the engine to work quite freely. In some cases this type of clutch, which is called the multiple-disc type, works dry, but in others it is kept lubricated. Both principles seem

to operate equally well. One set of discs is generally made of steel and the other set of phosphor bronze.

The plate clutch, of which several examples are to be found in notable cars, is really a disc clutch reduced to its simplest possible terms, as in this type only a single disc is used. The working surfaces are, of course, metal to metal, so that the clutch is capable of giving indefinite wear.

There is also a further type of clutch, which, however, is not so much used nowadays as at one time it was, and which is perhaps more suitable for high-powered cars than those of medium size, and this is the expanding metal clutch. A cup or drum is cast on to the flywheel, and in this are placed two semi-circular metal shoes, which exactly fit its internal periphery, and are held pressed tightly against it by a spring. By means of a simple mechanism connected with the clutch pedal these shoes, which are on opposite sides of the shaft, can be contracted or drawn towards one another, thus coming out of engagement with the flywheel drum. This type of clutch generally runs dry, or at most has occasionally a spot or two of oil to prevent it becoming harsh and sudden in action.

The leather clutch itself is made in two types, both of which work in exactly the same way, and are known as the internal cone and the external cone. In the one case the clutch is withdrawn by pressing it further into the flywheel, and the other

by withdrawing it from the flywheel. The advantage of the former system is that the spring for operating the clutch can be self-contained, so that when the clutch is working as a coupling no thrust is imposed upon the bearings of the crank shaft, though as a matter of fact this same advantage can be embodied in the external type, which has the further advantage of being more easily taken to pieces when required.

In the next section the gear box will be dealt with, and it now need only be pointed out in connection with the clutch that between the latter member and the gear box the drive from the engine is taken through a shaft, which is universally jointed; that is to say, rendered to a certain extent flexible, so that distortions of the frame, caused by passing over rough roads, do not impose any additional stress on the bearings, which would, of course, be the case if the clutch shaft were a rigid piece of metal.

Section X.—The Gear Box and its Functions: The Principle on which it Works and its Method of Operation—The Epicyclic Gear

The function of the gear box is to allow the engine to deal with different loads, which are imposed by changes in the gradient of the road upon which the car runs, starting and stopping, etc. If the engine were to drive the back wheels direct

through a clutch, an impractical state of affairs would exist, because the engine gives its full power on very high rates of revolution, up to 3,000 r.p.m., whereas the road wheels of an ordinary car do not have to turn round more than about 600 r.p.m. to give a speed of 60 miles an hour. Even if a suitable gear reduction to accommodate this difference were provided, the car would still be unworkable unless the engine were extremely powerful.

In starting the car from rest, the resistance, due to inertia, which is to be overcome, is very high, and as the engine can only be turning over slowly when the clutch is engaged, unless one wishes to rip the tyres off the wheels, its power output is very low. To meet this, the gear reduction between the engine and the rear wheels has to be made a very large one, and it will be readily understood that if one were to have the benefits of easy starting, and only a single gear were employed, one would have to be content with a maximum speed of about fifteen miles an hour on the level, at which rate of travel the engine would be roaring round at a tremendous number of revolutions, and actually giving far more power than was being used by the car. When the car is once on the move, a higher gear can be used.

Again, all roads are not level, and it stands to reason that when a car is propelling itself forward as well as lifting itself away from the centre of the earth against gravity, which takes place when it is ascending a hill, greater power is required to

propel it at a given speed than on the level. This power can only be obtained from a petrol engine by supplying more gas, or by allowing the engine to increase its speed. The former is strictly limited in its application, and if it alone had to be relied upon, an engine of huge size would be necessitated which would be uneconomical, excessively expensive, and dangerous. Hence it is necessary to allow the engine to run at a different speed, so as to give more power, and for this purpose a change of gear ratio between the motor and the back wheels is provided in the gear box. This consists of an arrangement of toothed pinions, which allow two, three or four different gear ratios to be employed as the case may be. At a thousand revolutions of the engine the first will represent, say, ten miles an hour; the second gear twenty miles an hour; the third gear thirty miles an hour, and the fourth forty, though of course the different ratios vary with the different cars, according to their power and requirements.

The first gear is used for starting the car from rest on the level, and on gradients, and also for climbing exceedingly steep hills, as when the engine is revolving at a high rate of speed, and giving a great deal of power, the car moves forward quite slowly.

The second is used for ordinary steep hills, and the third gear likewise. The latter is also extremely useful for traffic work, as it enables the car to be accelerated more rapidly than when it is on the

fourth or top gear. This last in nearly all cases provides a direct drive from the engine to the back axle, and no gear pinions are therefore in use. This results in absence of noise, which is set up by the gear wheels when they are transmitting power. The sketch given herewith shows how the gear box works.

The shaft A, which is in line with the clutch

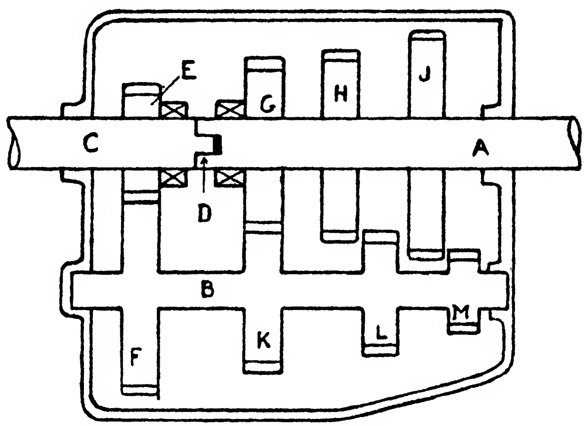


FIG. 7.

shaft, is called the gear shaft, and B is called the lay shaft. The clutch shaft C is not in one piece with the shaft A, but both can rotate independently of one another, alignment between the two being established by a spigot marked D. Mounted on the clutch shaft is a pinion E, which is in constant mesh to another pinion, F, so that this conveys power from the clutch to the shaft B. Fixed on the gear shaft A are three gear pinions, G, H, and

J, which mesh with pinions K, L, and M on the lay shaft. The former are not fixed in position, but are capable of sliding on their shaft on keyways or longitudinal grooves. In the position shown in the sketch the third gear is being used. The pinion E is rotating at engine speed, and this drives the pinion F round considerably slower, owing to the difference in their diameters. F carries the lay shaft round with it, and consequently K, L, and M rotate, but the two latter, being out of engagement with gear wheels, do no work. In the position shown the sliding pinion G is engaged with the fixed pinion K and the drive is taken through these two to the gear shaft A, which conveys it to the back axle.

The second gear, which is a lower ratio, is obtained by sliding G out of engagement with K and H into a mesh with L. L being smaller than K causes the shaft A to rotate at less speed, and the car therefore to travel slower. For first gear L is thrown clear from H, and J engaged with M, and M being smaller than L, a further decrease in the car's speed for the same number of engine revolutions is obtained. To obtain the fourth or direct gear, quite a different action is employed. On the sides of the gear pinions D and G, which face one another, are cut projections, which positively engage when the pinion G is slid towards D. When these projections are engaged, shaft C and shaft A revolve as one member, and there is no reduction of gear between the engine and

the back axle. This is known as the direct drive, the lay shaft and its pinions revolving quite idly, and doing no positive work.

The sketch shown is purely diagrammatic, and adopted simply to make the arrangement as clear as possible. In actual practice certain variations are introduced. For instance, some of the pinions on the gear shaft may be slidable, and some of the pinions on the lay shaft, but the principle of working remains the same. In the diagrammatic sketch of the gear box the reverse gear is not shown. This is, however, very simply arranged, by fitting a suitable pinion on the gear shaft, and engaging it with another pinion on the lay shaft through the medium of a third pinion, which meshes with both. This causes the rotation of the gear shaft to reverse its motion, and for general convenience, inasmuch as the car is never required to travel fast on the first gear, the ratio is generally made about the same as the first gear.

The gear boxes fitted to the earlier cars, and still used on one or two modern ones, are controlled by a lever working in a quadrant, which has a number of notches, which correspond to the number of different gear ratios available. The disadvantage of the straight-through quadrant was that it involved some little address on the part of the driver. Not only does he have to get to know the quadrant so as to get into the right notch without fail, but supposing he has been driving on top gear, and has to stop the car, and reverse

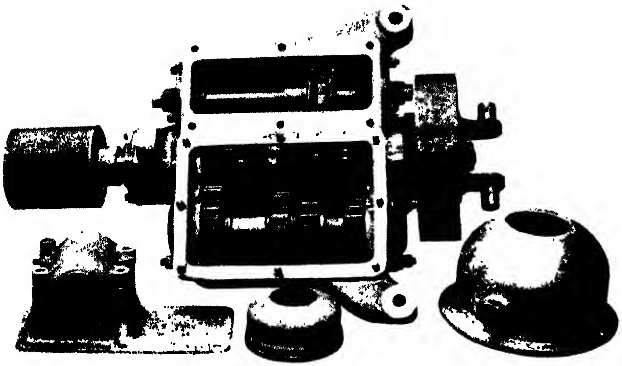
it, it is necessary to change from top to third, third to second, second to first, and first to reverse before the manœuvre can be completed. To overcome this difficulty, what is known as the gate type of change speed quadrant was designed. A single lever is employed, but each change of gear is operated independently of the others, and the lever moves in two quadrants joined together by a space which allows the lever to be taken from one to the other. These quadrants can be likened in plan form to a letter H, and the further advantage is gained that for every gear the lever has to be pushed forward or pulled backwards to its fullest extent—thus full forward on the left side operates first gear ; full back on the left side introduces second ; full forward on the right side engages third, and full back on the right brings the direct gear into action. If the lever lies as it were along the cross-bar of the H in either quadrant, the gear is in neutral ; that is to say, no pinions are working. This being the case, a direct change from third or top gear can be made to first or reverse without engaging the intermediate ratios.

All cars are not provided with four gears, though amongst the better class vehicles the four-speed box is a standard fitting, except in a few cases of six-cylinder cars of considerable size, where the flexibility of the engine partially removes the necessity for an additional gear. The three-speed gear box, which is employed on small and moderate-

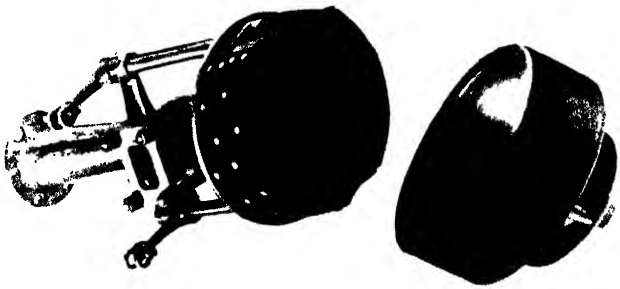
priced vehicles, works exactly the same as a four-speed, except that there are only three pinions on the gear and lay shaft in place of four. Some very small cars are only provided with two speeds, but this naturally reduces their effective range of utility, and either means that the range of speed on each gear must be considerably diminished, or some of the hill-climbing powers of the car must be decreased. Five- and six-speed gear boxes have been suggested, but their construction would offer so many complications and disadvantages that the benefits of the additional ratios would be largely lost, and it has been found that the best compromise from all points of view is the four-speed box.

Much has been promised for the epicyclic type of gear box, but this, although having certain advantages, has not yet obtained widespread support, although it is used on one or two cars, notably the Ford and the Lanchester. The principal advantages of this type of gear box are that the pinions are always in mesh, that is to say, they do not have to be forcibly engaged with one another, and consequently no skill is required to make a quiet and easy change of gear. The principle upon which they work is very simple, and may be followed in its essential principle by reference to the accompanying diagram.

A is a central pinion called a "sun" pinion, connected with the engine shaft. B are called "planet" pinions which form a connection between



A TYPICAL THREE-SPEED GEARBOX AND ITS CONNECTIONS OPENED FOR INSPECTION



A NEAT DESIGN OF BRAKE MECHANISM AS EMPLOYED IN THE MORRIS-OXFORD LIGHT CAR. EACH PAIR OF BRAKE SHOES IS SEPARATELY OPERATED, BUT BOTH APPLY ON THE SAME DRUM

the sun pinion, and a large internally toothed drum or pinion C. The planet pinions B are carried on spindles attached to a bracket, which in turn transmits the drive through the propeller shaft to the back axle of the car. If the drum C is locked to the frame of the car, as can be easily done by the application of a suitable form of brake, revolution of the pinion A causes the pinions B to "walk round," and a little consideration will show that the bracket which supports them revolves at half the speed of A. This gives a low gear. If by means of a second brake the bracket which supports the planet pinions is locked to the drum C, and the latter cast loose from the frame of the car, the whole gear box runs solid, and the driving shaft revolves at the same speed as the engine. This gives the high gear. If the drum C is allowed to run free by being locked neither to the bracket which supports the planet pinions nor to the car's frame, then no drive is transmitted at all, but the gear is in neutral, because the pinion A simply revolves B and the drum C quite idly.

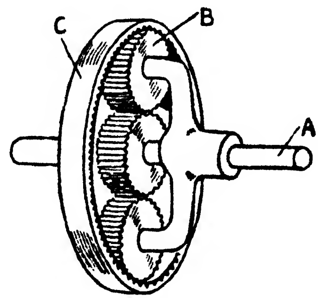


FIG. 8.

A reverse gear and a third gear can be obtained by running a second epicyclic train behind the other.

Section XI.—Transmission: Chain, Bevel, and Worm Drives—The Differential

In many of the earlier makes of car, and even to-day in some of the more highly powered Continental types, a chain drive is used. This is quite satisfactory and efficient, but it is not favoured as a transmission for lighter cars, though it has certain advantages of its own. The sketch herewith illustrates the arrangement of a chain-driven

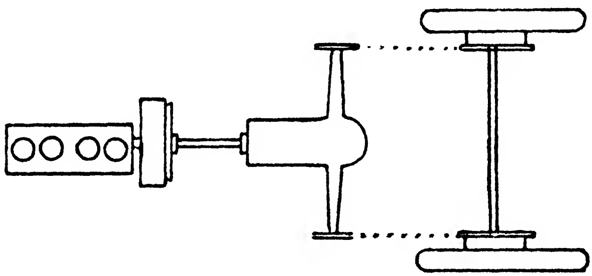


Fig. 9.

car, and shows how the engine is taken first to the gear box, then through bevel gears to a cross-shaft, and thence by chains running over sprockets to the rear wheels. In this case the back axle has no work to do except keep the wheels a certain distance apart, and support the weight of the car; hence it can be made quite simple and light, and its pounding action on the tyres, due to its weight being unsprung, is not great.

It will be noticed, however, that leakage of power

can occur at several points. Even on the direct drive a certain amount of efficiency is lost at the bevel gear of the cross-shaft, and a further percentage lost in the chain transmission. To overcome this, what is called the live-axle type of transmission has been evolved, and finds general favour with all automobile manufacturers. A general scheme of this is set out in the second sketch, from which it will be seen that the cross-shaft and the axle are here made into one, and therefore leakage of power

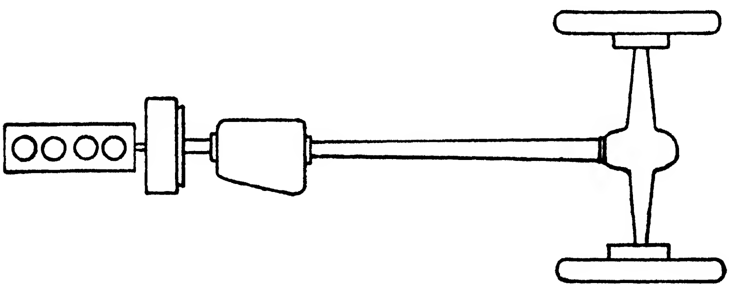


FIG. 10.

only occurs on the direct drive at one point. It is true that when this is done the amount of unsprung weight on the tyres is considerably increased, but on the other hand the whole of the transmission can be very completely enclosed against ingress of dirt and wet, which would otherwise greatly affect its efficiency, and this in the end becomes really a matter of more importance than the slight amount of increased wear on the tyres.

In some cases where cheapness of construction

is of importance the gear box itself is combined with the rear live axle instead of being directly supported by the frame. It is claimed for this arrangement that one has the advantage that the gear noises are not so easily heard, and that the increase in unsprung weight is not sufficient to make any noticeable effect on tyre economy.

Since, as can be seen from the sketch, it is necessary for the back axle shafts to be arranged at right angles to the propeller shaft, either a bevel gear or a worm gear has to be employed. The former enjoys rather more popularity than the latter, owing to the cheapness of its construction, but the worm gear has this great advantage, that it is always perfectly silent in operation. By dint of careful testing, however, a bevel gear can also be made quiet, and although the worm gear is capable of showing a higher efficiency of transmission, it is generally conceded that for allround purposes the bevel gear is equally good. Both types, therefore, can be expected to exist side by side for a considerable time. The pioneer of the worm drive was Lanchester, and it is significant that the Lanchester car of to-day is fitted with exactly the same transmission as the original type.

The worm pinion can be arranged either over the worm wheel or under. In the former case more road clearance is provided, but it is not possible to build the car quite so low as if the under type of work gear is employed.

The Differential.—If we take an empty cotton-

reel, and roll it across a table, it will be perceived that it insists upon taking a perfectly straight course. It cannot go round in a circle if the two rims are of equal diameter, because if it did the edge which was on the outside of the curve would have to make more revolutions than that which was on the inside, and as the two rims are solidly joined together this cannot occur.

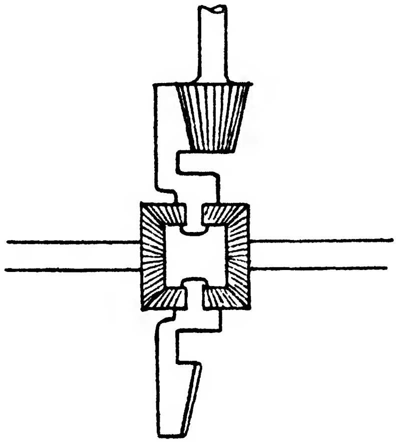


FIG. 11.

If the rear wheels of a car were joined together by a solid shaft, exactly the same thing would take place, and the car could only be driven round a corner by enforcing a violent slipping effect on one of the tyres. Needless to say such a principle would prove very expensive in covers, and hence a device has to be incorporated to overcome this objection. The device in question is called a

differential, and has for its object to provide a positive drive to each rear wheel, whilst allowing both to work independently of one another when circumstances such as turning a corner demand that one should outrun the other. This, therefore, does away with any slipping between the tyre and the road. The differential is quite a simple piece of mechanism, and it is arranged on the principle diagrammatically set forth in Fig. 11. Each rear wheel terminates at its inner end in a bevel pinion, and the two pinions so formed are interconnected by bevel pinions at right angles, which are mounted upon spindles carried by the crown wheel or worm wheel, which transmits the drive from the propeller shaft. If we imagine one of the axle shafts, that is to say, one of the road wheels, to be stationary, then a little consideration will show that the whole of the drive will pass to the other wheel, but that if both road wheels are loaded with an equal resistance, the drive will pass equally to both, the differential serving to provide a balancing effect between the two. Incidentally if the crown wheel is held stationary, then revolving one road wheel in one direction will cause the other wheel to revolve in the opposite direction. Some differentials are made with plain spur pinions taking the place of bevel pinions, but although the arrangement is different, the action is exactly the same, and a detailed description of the second type need not therefore be given. The bevel pinion, on

account of its greater simplicity and compactness, is, however, the more popular type.

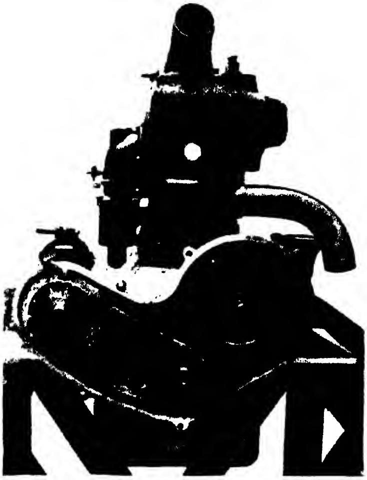
SECTION XII.—BRAKES: FUNDAMENTAL DESIDERATA—VARIOUS TYPES—THE COUNTER-SHAFT BRAKE—THE HUB BRAKE—FRONT WHEEL BRAKES

Not least amongst the important components of a car's mechanism are the brakes, for upon them depends the ability of the vehicle to be run without danger to its occupants, or to other users of the road. There are three principal arrangements of braking systems. In the standard form, that which is used on the immense majority of cars to-day the brakes are three in number, and consist of one which is applied to the propeller shaft immediately behind the gear box, and of two which operate directly upon drums attached to the rear wheels. A little consideration will show that this construction results in the brakes being of an entirely different character. Since there is a considerable gear reduction between the propeller shaft and the rear axle, the former revolves at a higher speed than the road wheels, and therefore a less pressure is required to apply the same frictional resistance on the former than on the later. Moreover, the counter-shaft brake works through the differential, and does not affect the independence of the back wheels to follow any curved course set by the front wheels of the car. This means

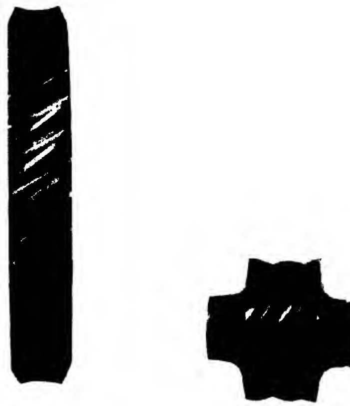
that by the use of the counter-shaft brake a very quick pull-up can be effected, but on the other hand this is mitigated against by the fact that if one wheel should tend to slip on the road more than the other, much of the braking effect is lost.

To make sure of safety, therefore, the directly applied hand brakes, which work on the rear wheels, have to be used as a stand-by, the counter-shaft brake being operated by a pedal under the driver's right foot. The counter-shaft brake generally consists of a drum, in which metal shoes of semi-circular shape are caused to expand by means of a cam action, and the same design is commonly also applied to the rear wheel brakes. In some cars, however, the counter-shaft brake consists of two external shoes, which are contracted on to the outside periphery of the drum. The shoes are sometimes lined for part of the surface with an asbestos composition, which renders them less harsh in action and more proof against failure through oil getting on to the surfaces.

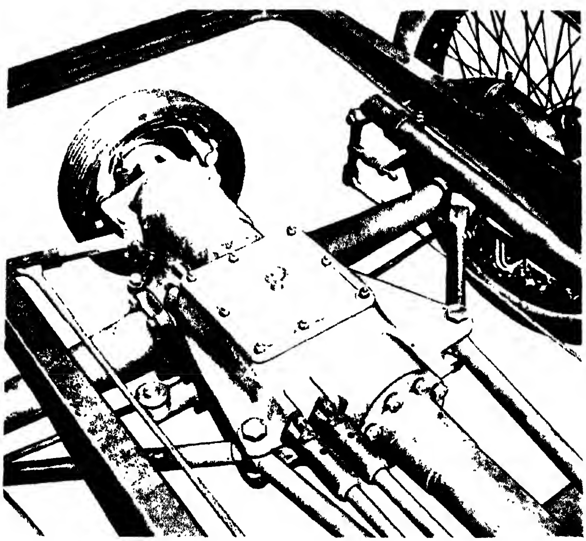
In order that the rear brakes may be both worked equally when the pressure is applied by the hand lever, a form of balance gear is introduced, and generally consists of a lever connected at either end to the brake-operating mechanism, and fitted with a link in its centre, which proceeds to the brake lever. Should the brakes wear unevenly, this discrepancy is immediately taken up automatically, and under all circumstances an equal pull is put upon each brake. It is becoming



THE "DISTRIBUTION" OR VALVE GEAR OPERATING MECHANISM OF THE 12-H.P. ROVER



A TYPICAL "STRAIGHT" WORM WHEEL AND PINION AS USED IN BACK AXLES



THE INTERESTING BRAKE DESIGN OF THE 20-H.P. DAIMLER CAR. THE PROPELLER SHAFT IS EXTENDED BEHIND THE BACK AXLE TO CARRY THE BRAKE DRUM

nowadays rather more common to find that both the hand and the foot brakes are applied directly to the rear wheels, but it is a moot question whether this principle has any positive advantages, though in regard to construction it allows of a rather easier attachment of the propeller shaft casing to the gear box, and this is probably the chief reason why it is coming into favour.

In this case the rear wheel hub drums either contain two pairs of expanding shoes placed side by side, or else in addition to the internal brake the contracting band brake is applied to the outside periphery.

The third system of braking, in which all four wheels are furnished with a frictional resistance, came into favour a few years ago, but afterwards practically disappeared, owing to certain difficulties in the construction not being properly provided against, and at present very few cars are fitted with brakes on all four wheels; but where the construction is properly carried out it is a most successful arrangement, and renders a car practically secure against any likelihood of skidding, even under the worst conditions.

Section XIII.—Suspension: A Variety of Types —The Function of the Springs—How they are Generally Arranged

There are so many different types of springing in use on modern cars, that to attempt to describe

them all would occupy far too much space, and they can only therefore be now briefly reviewed. For the front wheels of the car, half-elliptic springs consisting of a number of leaves placed one above the other are almost exclusively used, whilst for the rear wheels, half-elliptic and three-quarter elliptic springs are in most common use. These types are

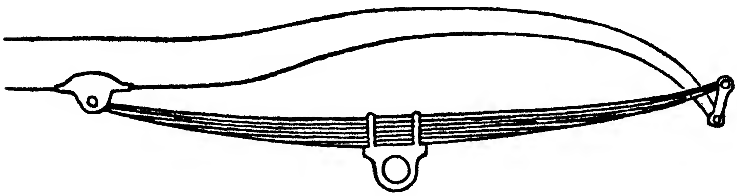


FIG. 12.

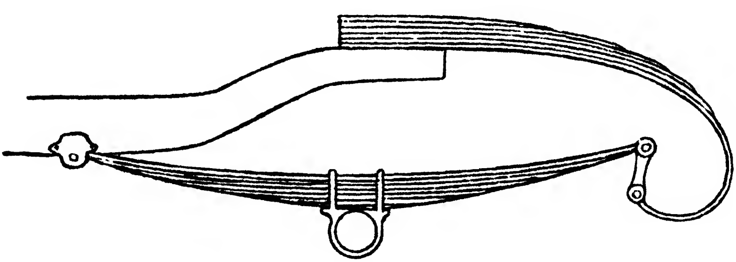
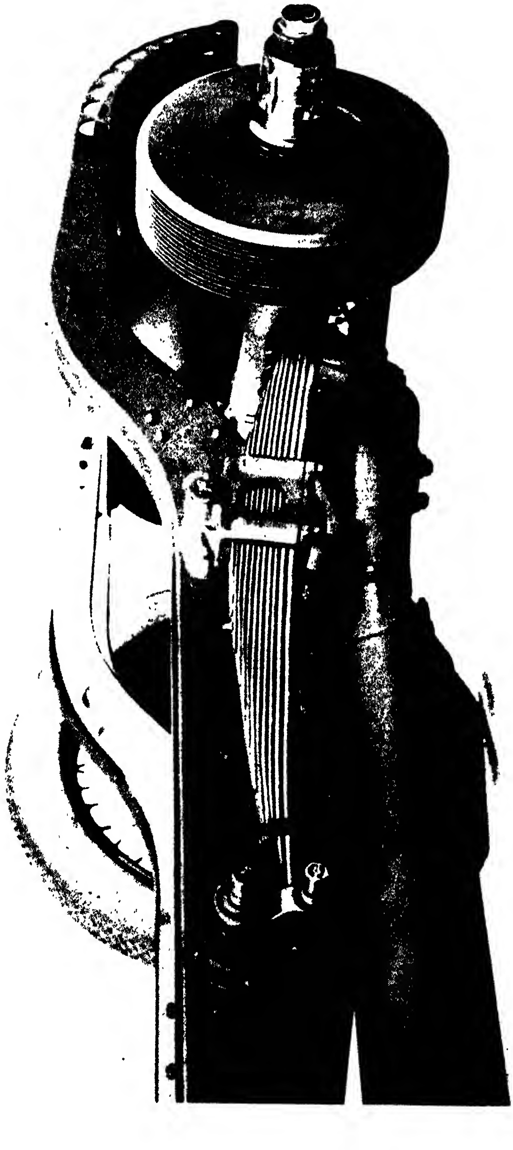


FIG. 13.

illustrated, and it may be said that there is very little to choose between them in point of comfort and efficiency. Providing the half-elliptic spring is made long enough, it is capable of yielding great comfort, and of resisting the tendency for the car to roll when corners are taken at some speed. Both these types have the objection that most of



the weight of the springs is carried on the axle, and adds to the unsprung weight, which, as has already been pointed out, has a malignant influence upon tyre wear.

Even in his earliest car, Lanchester realized the importance of this point, and devised a method of springing which has rapidly come into more and more favour. This is known as the cantilever type, and in addition to being found on the Lanchester car, is used in a modified form on several others, notably the Sheffield Simplex, Rolls-Royce,

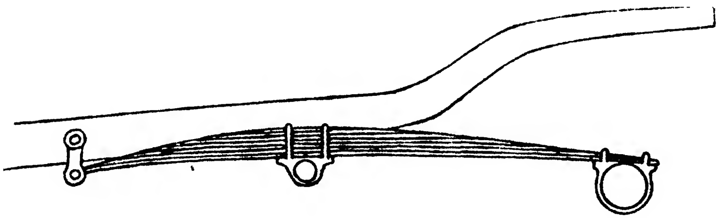


FIG. 14.

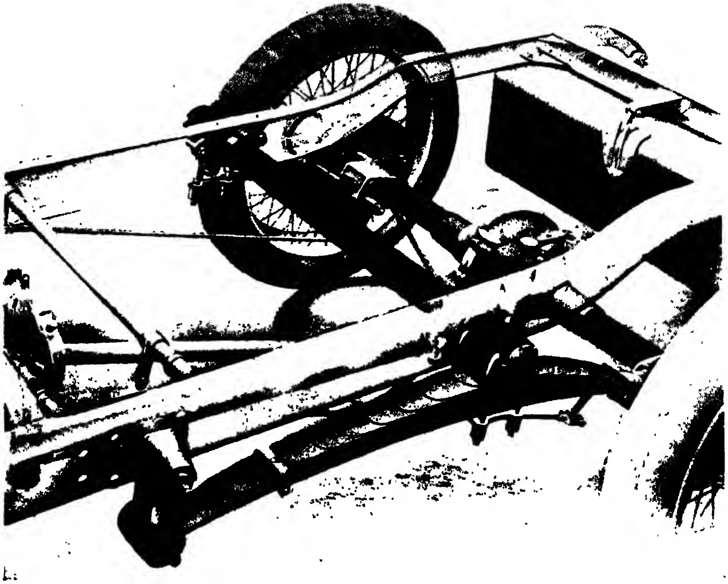
Siddeley-Deasy, and Daimler chassis. As is shown in Fig. 14, the movement of each axle (for the Lanchester springing applies both to the front and to the rear) is restrained by two parallel links, the spring being firmly fixed to the chassis frame, and attached to the axle in such a way that it can slide easily to take up the difference in motion. In the Rolls-Royce and Sheffield Simplex cars, these links have their place taken by the casing of the propeller shaft, which is formed with a globular joint at the gear-box end, and so compels the wheels to move

up and down along the path of an arc struck from this point.

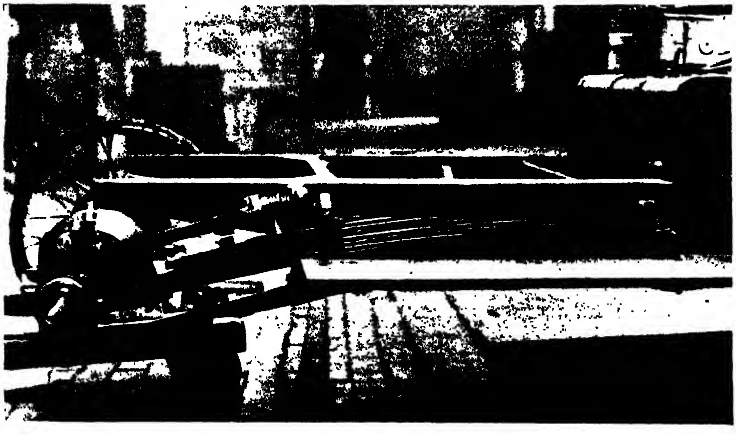
In the latest Wolseley cars cantilever springing is used and the arrangement is similar to that adopted on the Rolls-Royce except that in this case the two trunnions which support the springs on either side of the car are joined together by a rod which prevents one working independently of the other. The object of this patented device is to prevent "rolling," but it is difficult to see how this end can be attained without militating against the general flexibility of the general suspension, inasmuch as "rolling" is only the converse of the phenomenon which occurs when one wheel is affected by an obstacle and the other is not.

In a number of American cars a single transverse rear spring, which is a development of the half-elliptic, is employed, and radius rods are used to make the axle move up and down in the desired manner. Sometimes the forward part of the half-elliptic spring itself is used as a radius rod or link, and in this case it is shackled at its rear end, and pivoted at its front end, but in other cases it is shackled at both ends, and the tubular casing of the propeller shaft spherically jointed to the gear box is used instead.

A little consideration will show that when the power is applied to the car when at rest, there is just as much tendency for the engine to turn the axle casing around the stationary axle shafts as to



THE PATENTED FORM OF REAR SPRINGING USED ON WOLSELEY CARS. THE CROSSBAR CONNECTS THE SPRING TRUNNIONS AND TENDS TO MAKE THE SPRINGS WORK TOGETHER



THE ORIGINAL CANTILEVER SPRINGING INTRODUCED AND STILL USED UPON THE LANCHESTER CAR

turn the axle shafts in the wheels round against the stationary axle. This reaction is met by what is called a torque member, which sometimes consists of a long lever secured to the axle, and extending forward to a convenient cross-member of the frame, to which it is articulated with a stiff spring to give it a certain amount of freedom of motion. Where a propeller shaft casing is used, this can act as a torque member, but sometimes the front portion of a half or three-quarter elliptic spring is made to serve the same purpose, and in this case the axle is directly bolted to the springs so as not to have any freedom of motion in relation to them. Where the spring does not take the torque, its platform on the axle casing is furnished with a bearing or trunnion, so that the springs are not deformed by the slight rotary motion of the axle which is involved in its moving up and down in a curved path.

Since the engine power is applied to the rear wheels, some connection has to be made between the rear axle and the frame to take the thrust which is necessary to push the car along. Separate members for this purpose are sometimes used, and known as radius rods, but where the propeller shaft casing is spherically jointed this member performs that function in addition to acting as a torque member. If the spring is made fast to the axle, then it can also take the thrust.

In the case of the Lanchester springing, the two links, one above and one below the spring, support

this thrusting action, and one of them is made very slightly telescopic against a pad of rubber, so that any harshness in action is damped out. This applies both to the torque and the thrust.

Section XIV.—Control: How the Speed, the Acceleration, and the Pulling Up of a Car are Effected

In the early days of the motor-car various systems of control were employed, but nowadays this feature has become practically standardized. On the steering wheel are fitted two levers, one of which controls the throttle in the carburettor, whilst the other operates the advance or retard of the ignition. If necessary one can drive the car by means of a throttle hand lever, but generally this is only used to set the carburettor, so that the engine continues running when the foot is released from the accelerator pedal. The latter is also connected to the throttle, and whilst able to open it to its fullest extent, is thus prevented from absolutely closing it. In some cases an adjustable stop acting on the throttle or accelerator pedal is installed in place of the hand lever on the steering wheel. The brake pedal is under the driver's right foot, and the clutch pedal under his left, and sometimes the throttle pedal is on the extreme right of both, and sometimes between them. Which is preferable is largely a matter of taste.

Section XV.—Steering: The Usually Adopted Mechanism Described and its Principle Made Clear

The steering of motor-cars is almost universally effected on what is known as the Ackermann system. In this the front axle is rigidly attached to the springs in the front of the car. At each extremity is pivoted a short arm, which is free to turn through a horizontal radius on the end of the fixed axle. On these two arms are mounted the front wheels, ball-bearings being generally employed.

Other short arms forming part of the two pivoted arms project towards the front of the car, and their ends are connected by a link rod parallel with a fixed axle, so that the turning movement of one wheel is communicated to the other. The direction of the road wheels is controlled by the driver by means of a small hand wheel fixed on a sloping pillar, and the turning movement of this wheel is communicated by worm gearing to one of the pivoted steering arms. The ratio of this worm gearing makes it easy for the driver to deflect the road wheels by a slight movement, but almost impossible for the steering wheel to be deflected through the road wheels by inequalities in the road service.

Section XVI. — Electric Transmission: Its Advantages, Disadvantages, and Possibilities

From what has been said already of the petrol engine, and the necessity for employing different gear ratios, it will be apparent that the ideal result could be obtained by incorporating some form of transmission which enabled the gear ratios to be infinitely varied to suit all possible conditions. Many mechanical devices have been designed to achieve this end, but so far as motor-cars are concerned they have one and all been more or less hopeless failures, with the two exceptions of a hydraulic gear and an electric transmission. The former is only of service for very heavy vehicles running at a slow speed, but the latter has many possibilities, and has already been demonstrated to be a thoroughly practical system, even applied to a comparatively small car.

At present the principal obstacle in its progress is its cost, but no doubt in course of time this difficulty will be, if not overcome entirely, at any rate compromised with. Electric transmission is used on a large number of motor buses running all over the British Isles, and several systems, each having detail differences, have been materialized. The Thomas electric transmission, which had the distinction of winning the Dewar Trophy given by the Royal Automobile Club for the best

performance in the year 1911, works briefly as follows :—

The engine is coupled to a dynamo, which generates current, and supplies it to a storage battery, and also to an electric motor, which drives the rear wheels through a propeller shaft and live axle. By means of an electric controller any ratio of gearing can thus be obtained, and the need for a clutch or change-speed gear box is entirely done away with. In order to provide a positive direct drive, a mechanism is installed which directly connects the engine shaft with the propeller shaft, so soon as the latter turns at the same speed as the former. Thus while the car is on its top gear or direct drive, the electric transmission is idle. Consequently a very high standard of efficiency is maintained. The storage batteries are used to start the engine up through the dynamo, to light the car, and also, when necessary, to move it about from place to place over short distances, when it runs as a purely electrical vehicle. By means of a regenerative system of control the impetus of the car when coasting down hills can be used to return electric current to the batteries, the driving motor being in this event used as a dynamo.

In the electric transmission used on motor buses the engine drives a dynamo, which is connected to a motor driving the propeller shaft, arranged in such a manner that it can be run either as a series- or shunt-wound machine. No batteries are

used for storage purposes, and, as before, the need for a clutch and gear box is done away with. This system is, however, not suitable for high-speed light cars.

Section XVII.—Sleeve Valve Engines: How They Differ from the Type Already Described and Their Advantages

Although by means of poppet or mushroom valves very high efficiencies can be obtained from an internal-combustion engine, this type of valve mechanism has certain disadvantages, which have, however, not been sufficient to cause it to be superseded. One of these disadvantages is the liability of the valve to break when the engine is running under full load for considerable lengths of time on end. Another disadvantage is the noise set up by the cams and tappets, which are used to lift the valve from its seat. Several types of mechanically operated valve, which do not suffer from these disabilities, have been proposed and experimented with, but the only two really successful alternative systems of valve mechanism are those which are used on the Daimler and Argyll cars respectively. On the former the engine is of the Silent-Knight type, and this is also employed on the French Panhard, the Belgian Minerva, the German Mercédès, and the British Siddeley-Deasy, the B.S.A., and a large number of American vehicles. In this engine the valves

consist of two concentric sleeves, which are placed between the piston and the cylinder wall. Each of these valves is separately operated by an eccentric and crank driven by a shaft, which runs at half the speed of the engine. They each contain admission and exhaust ports, which are adapted to be brought opposite one another, and to establish communication between the combustion chamber and the carburettor, or with the exhaust pipe at the correct time, by means of the action of the eccentrics.

It will be realized that as these valves slide upon one another they set up no noise.

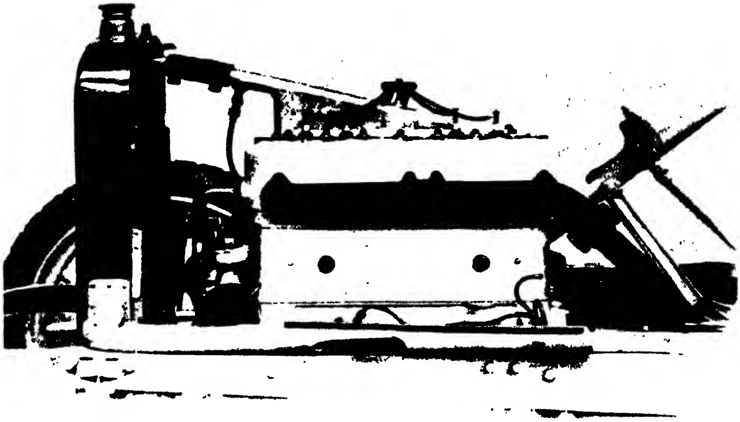
A further advantage is that owing to the peculiar motion imparted by the eccentrics, the opening and closing of the valve ports is effected very rapidly, so that the cylinder has no tendency to be starved of mixture at high speeds. The Knight engine holds all records for durability as far as running continuously under full load is concerned, but has never achieved any distinction in high-efficiency racing work, although the number of its devotees for touring cars is certainly increasing every year.

The Argyll single-sleeve valve engine comprises a mechanism which achieves exactly the same end in a different manner. In this case only one sleeve surrounds the piston, and, as before, lies between it and the cylinder wall proper. It is moved up and down by a small crank, which also imparts to it a rotary motion,

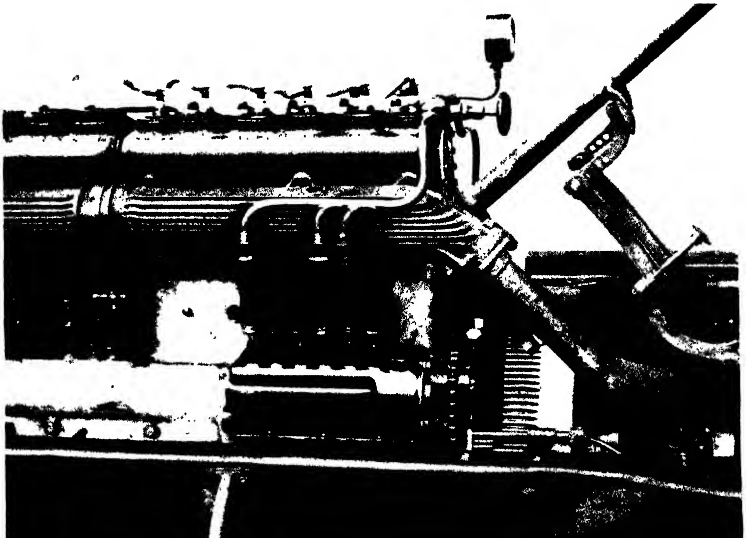
so that any point on the valve actually describes an ellipse, and for this reason the engine is sometimes called an elliptical valve motor. Ports are cut in the sides of the cylinder above the piston, and these are brought into register with ports in the sleeve valve at the correct times for opening and closing the inlet and exhaust. This engine has shown itself capable of doing some very fine speed work at Brooklands.

Section XVIII.—Electric Lighting Dynamos: Working Principles and Variety of Types Described

No apology is needed for including a description of the lighting dynamo amongst the other connections of the petrol motor, for as a source of light, which is necessary on practically all cars, electricity has practically secured pride of place, and in course of time must become a standard fitting. Over any other form of illuminant electricity has great advantages, as it is perfectly steady under all conditions, is actually cheaper to maintain, and gives a greater optical efficiency. It also enables the lamps to be lit without requiring any one to get out of the car. Electric lighting dynamos for motor-car work are quite a specialized product, and differ from the commercial lighting dynamo in this respect that they must be capable of giving a practically constant output of current, irrespective of the speed at which they are being driven. They



NEAT ENGINE DESIGN AS EXEMPLIFIED IN THE FOUR-CYLINDER 16 H.P. SUNBEAM MOTOR



THE SUNBEAM COMPRESSED-AIR SELF-STARTER ATTACHED TO A SIX-CYLINDER ENGINE. NOTE THE SMALL ENGINE WHICH DRIVES THE FLYWHEEL THROUGH A RACK

would be useless if the volume and pressure of the current were continually changing. In some dynamos, notably the C.A.V., which was the first to show that electric lighting for cars was a practical possibility, an ingenious use is made of certain reactions which occur in a dynamo when part of the armature wiring is short circuited, and by this means the output of current is kept practically constant at all speeds of rotation above a certain point. In other cases a centrifugal governor is employed, which limits the maximum speed at which the dynamo can be driven, constant output being thus attained in a purely mechanical manner. In other cases a special form of resistance, either in the shape of a coil or of a trembler, is introduced, so as to prevent the dynamo passing more than a fixed charge to the storage batteries. The latter are used in all systems, in order to prevent any damage to the lamps, which would probably occur if the dynamo were caused to light them direct, and also to provide current for them when the engine is at rest and the dynamo not in action.

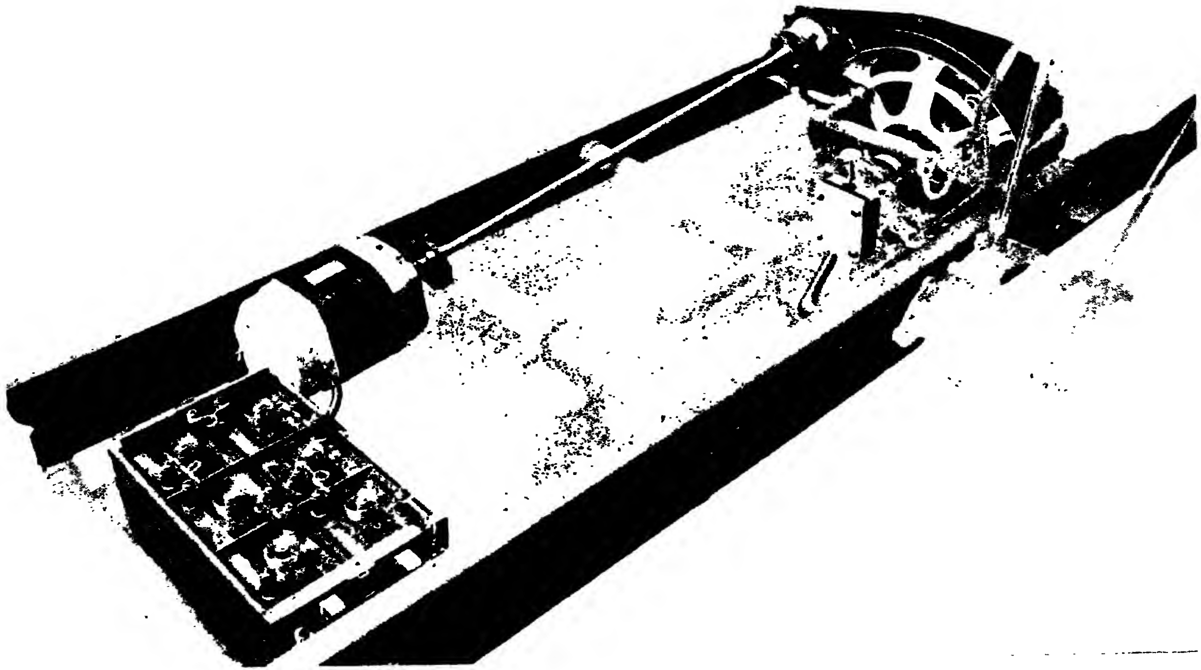
Section XIX.—Self-starters: How These Labour-saving Appliances Work

It is only within the last year or two that attention has been given to increasing the comfort of motorists by providing an adequate means for automatically starting the engine, in place of the laborious and even dangerous starting handle.

For this great improvement we owe thanks to American designers, who have shown themselves far less conservative than their European cousins in regard to providing devices for increasing the comfort and convenience of the car user. The most popular type of engine starter is the electric, which is particularly convenient because it can be so easily used in conjunction with an electric lighting outfit, the current for it being provided by the lighting dynamo.

The electric motor generally turns the engine through the agency of a cog wheel and a rack cut in the rim of the flywheel, and is set in motion by pressing a switch. Means are provided to throw it completely out of action when the engine has already started. In some designs the pinion and rack has its place taken by a friction roller working on the flywheel.

In addition to the electric type, there are other self-starters, notably the Wolseley and the Sunbeam, both of which employ compressed air. In each case the engine is adapted to drive an air compressor pump, which fills a strong steel bottle with air at very high pressure. In the case of the Wolseley, this compressed air is directed into the engine cylinders by means of a special form of distributor valve, and thus sets it in motion, whilst in the Sunbeam arrangement a separate three-cylinder starting engine is provided, which turns the petrol motor through a pinion and rack cut on the flywheel.



ARRANGEMENT OF A C.A.V. SELF-STARTER ON A CHASSIS, SHOWING STARTING MOTOR, BATTERY AND FRICTION DRIVING-WHEEL

Other forms of self-starter have been introduced, and have had a limited vogue, amongst which may be mentioned one or two of the clockwork type, which are adapted to be fitted quite easily to existing engines in the place of the starting handle. In these devices a long clock spring of great power is employed to spin the engine for a few revolutions, and an ingenious gear is embodied, by means of which the engine winds up the spring as soon as it has run under its own power.

Of the three forms of starter there is no doubt, however, that the electric type will eventually supersede all others, principally because it will run an engine for upwards of twenty minutes on end, and is sufficiently powerful to drive the whole car along if the bottom gear is engaged. This means that if the petrol tap should have been carelessly turned off, or the ignition switch not left on, these faults can be remedied before all the starting power is wasted.

Furthermore, electricity, in addition to lighting the car, can be employed for warming it in winter and cooling it by means of a ventilating fan in summer. It is also useful for artificially heating the carburettor, for cigar-lighters, etc., and will probably come into extensive use as an agency for effecting gear changes, operating the clutch, and applying the brakes. At all events this at least comes within the range of distinct probability.

CHAPTER IV

SOME TYPES OF PETROL CARS

1. Cars from £115 to £250: The G.W.K.—The Ford—The 9·5 Standard—The Singer light car—The Overland
2. Cars up to £350: The 12 h.p. Rover
3. ,, ,, £400: The 16 h.p. Sunbeam
4. ,, ,, £550: The 16/20 Wolseley—The 25 h.p. Vauxhall—The Cadillac
5. Luxury cars: The Rolls-Royce—The 38 h.p. Lanchester—The 30/36 six-cylinder Siddeley-Deasy

IT is manifestly impossible with the many hundreds of different makes of car at present on the market to deal with more than a very small proportion of representative types in a chapter devoted to the consideration of the state to which automobile design has been brought, and it is therefore proposed to deal in some detail with a few notable chassis. There is, of course, an almost infinite number of gradations between the light car, with its tiny little engine and two-seater body, and the large vehicle of 50 h.p., that whisks along with a huge limousine body as though it had no load at all. It has therefore been thought advisable to divide this long range of cars into five representative classes: 1. Cars from £115 to £250;

2. Cars up to £350; 3. Cars up to £400; 4. Cars up to £550; 5. Luxury cars.

1. Cars from £115 to £250

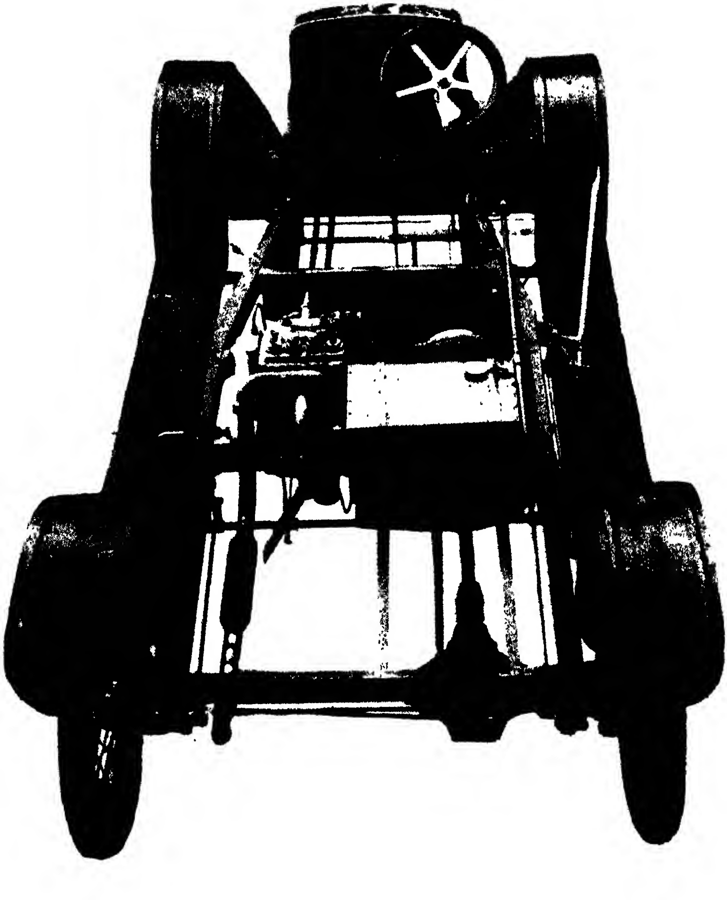
In this section the two representative makes taken for illustration are the G.W.K. and the Ford.

The Ford car, which is in certain respects America's most important achievement in automobile design, comes nearer to being a universal car than any other that has been ever put upon the market. It is found doing all kinds of service in all corners of the globe, and has undoubtedly done more to bring motoring within the grasp of the man of small means than any other design. It is sometimes wondered why other countries could not produce a car on similar lines. The answer is simply that although they have the manufacturing facilities and the supplies of raw material, etc., are equally available as in the United States, they have not at command so enormous a public ready to consume the major portion of their output.

The G.W.K. Car.—This vehicle was one of the first to appear on the market as a compromise between the motor-cycle type of vehicle and the large car, but unlike many others which were evolved for the same purpose, it is designed on quite distinctive and individual lines, embracing many points of exceptional interest. Two radical departures from ordinary accepted design lie in the

fact that the engine is not placed under the bonnet in front, but at the back of the driver's seat, and that the transmission is by means of a variable friction disc. In regard to the latter, it has long been sought by motor engineers to provide a thoroughly satisfactory friction drive, as this system offers so many advantages in point of simplicity and ease of construction. It may, however, be said that the G.W.K. is the first vehicle so fitted to attain any great popularity, and also that it is the first of its kind to show that friction drive, when properly designed, is at least the equal of any other type of transmission for light cars.

Before proceeding to describe the vehicle in detail, it is as well to point out that one great advantage of the fact that the engine is placed amidships and not in front, is that the weight of the car is very evenly distributed, and in fact there is more on the rear wheels than on the front, which is exactly as it should be. Moreover, the fact that the seats do not have to be placed far back to allow plenty of leg room behind the engine results in their being situated almost midway between the front and rear wheels, so that the maximum of comfort is assured to the passengers. This is a very important point, and apart from its proved reliability and hill-climbing efficiency there is no doubt that much of the G.W.K. popularity is attributable to this point. The frame is of pressed steel of U-section, sharply narrowed in front to give a large steering lock to the front wheels. It terminates in



GENERAL ARRANGEMENT OF THE G.W.K. LIGHT CAR CHAINS. A FRICTION DRIVE IS EMPLOYED AND THE KEYNOTE IS GREAT SIMPLICITY

front in a cross-member, which serves to support the radiator, which is of the vertical tube type, immediately behind which is the steering pillar and its connection and the pedals through which the car is controlled. The engine is carried a little to the rear of the centre of the frame, and is stoutly supported on two cross-members. It is of the two-cylinder type, having a bore and stroke of 86×92 mm. and a R.A.C. rating of 9·2 h.p. It is fitted with a balanced crank shaft, with the cranks set at 180 degrees, and a notable feature is that this shaft runs on ball-bearings. The cam shaft is driven by a silent chain, and the whole of the valve mechanism is adequately enclosed. The magneto is driven by chain, and the carburettor, which is a Solex, giving automatic action at all speeds, is carried in such a position as to enable a supply of warm air to be drawn through a box surrounding the exhaust pipe. The lubrication system is extremely simple and works on the splash principle, the crank chamber being fed with oil from the tank by means of a hand pump, which is worked so often as is necessary to maintain a practically constant level of oil, into which dippers on the connecting rods splash, the resultant spray being directed to all moving parts. Since the radiator is in the front of the car, and the engine in the middle, it is obvious that thermo-syphon cooling cannot be employed, and a centrifugal pump is therefore fitted, which ensures that the engine keeps cool under all conditions. The crank shaft being set at right

angles to the plane of the frame, the starting handle is at the side of the car instead of being in front, and the flywheel rotates in the same plane as the road wheels.

In the G.W.K. there is no clutch or gear box of the accepted form. The flywheel is of large diameter, and fitted with a perfectly smooth surface, which acts as a friction disc. At right angles to this is another friction disc, the edge of which is lined with a special material which can easily be replaced should any undue wear occur. This second friction disc is mounted on a castellated shaft, which allows it to be moved nearer or farther from the centre of the flywheel, thus providing an infinite number of different gear ratios from maximum to minimum. As a matter of fact the gear lever which operates this movement is furnished with five notches, giving four forward speeds and one reverse. The action of a clutch is furnished by means of a pedal, upon pressing which the driven friction disc is drawn out of contact with the flywheel so that the engine runs perfectly free. The shaft on which the driven disc is mounted is, of course, lengthways with the car frame, and terminates in a universal joint, through which the power is transmitted through a cardan shaft to the rear live axle. In order to allow for the driving shaft not being central in the chassis, the differential is mounted very much nearer the off-side wheel than the near-side wheel, but this, of course, makes no difference to its compensating action. The final

drive is by bevel, and the torque reaction of the axle is sustained by a special tubular member mounted on the axle casing, and extending forward to the cross-member, to which it is articulated. In front the suspension is by semi-elliptic springs, and in the rear quarter-elliptic or grasshopper springs are used. These serve to take the driving effort of the back axle, as well as to support the weight of the car. They give very easy riding under all circumstances. The steering is by a large hand wheel working the front wheels through a rack and pinion. It gives very easy handling, but is, of course, not entirely irreversible, though with a car of a low weight, such as is the G.W.K., this matter is of no very great importance. The wheels all round are of the wire spoked type, furnished with 650 × 65 mm. tyres. The hand brake, which is operated by a tubular side lever in the usual way, takes the form of expanding shoes in the rear-wheel hub drums, and therefore follows ordinary car practice, but the foot brake is on quite novel lines, which are rendered exceedingly simple by the arrangement of the friction transmission. There is no separate brake pedal, the clutch pedal acting in this capacity when it is fully pressed down. When this is done it first takes the driven friction disc out of contact with the flywheel, and then forces a brake drum carried on the same shaft as the disc against a fixed shoe attached to the frame. One thus has an extremely efficient and simple form of counter-shaft

brake, which imposes the minimum strain on the transmission generally. The front axle is of tubular construction, and is very light and strong. The complete vehicle is equipped with a very neatly designed two-seater body complete with scuttle dashboard and high side doors. Although the car has what appears to be a bonnet, this is really only a cover for the compartment in which the driver and passengers have their feet, and between which and the radiator is another compartment allowing a full draught of air to pass through the latter and emerge at the sides of the bonnet.

Access to the engine is obtained through a folding flap immediately behind the seats, and behind the engine compartment in the tail portion of the body is a commodious tool locker. A neat hood and wind screen are fitted, and the appearance of the car is very taking indeed. The wheel base is 7 feet 7 inches, the wheel track 3 feet 9 inches, overall length 10 feet 6 inches, and the overall width 4 feet 8 inches. The price of the G.W.K. car complete with hood, screen, lamps, and horn is 170 guineas.

The Ford Car.—Since only one type of chassis has been made for the last ten years, and since such alterations as have taken place in it have been limited to improvements in material and trivial details, the makers of the Ford car can justifiably claim that no car in the world has been so much the subject of specialized attention. The Ford was

the first vehicle to be put upon the market with a specification that could compare with that of a large car, and in this class it has for long set a standard of quiet running, comfort and other admirable qualities, that has succeeded in making it the most popular car in the world. Upwards of three-quarters of a million vehicles of this make are now running, and as the present output of the factory is now over three hundred thousand a year, the immense scope of this car will be realized. It differs from all European solutions of the cheap car problem in having what is relatively quite a large engine. This, however, is neither expected nor intended to give a very high rate of working efficiency, but the fact that it is of large proportion ensures that it can give a reasonable output of power even after long use, when a more highly efficient engine of smaller size would have begun to feel the effects of wear and tear very much more. In like manner the Ford does not pretend to be a fast car. Occasionally it can be accelerated up to about 40 m.p.h. and even more, but generally speaking it is designed to run at a maximum of 30 m.p.h., and the power which the engine gives at low speeds enables a very good average speed to be maintained without unduly pushing it under unfavourable conditions. The engine is a four cylinder, with the cylinders cast *en bloc*, and is rated at 20 h.p. The bore and stroke are respectively $3\frac{3}{4} \times 4$ inches. The crank shaft is supported on three bearings, and for the sake of ease in production

the cylinder casting and the upper half of the crank chamber which supports the crank-shaft bearings are in one piece. A particular feature of the Ford engine design is that the cylinder heads are detachable, giving at once access to the valves, pistons, and the water jackets. This is an extremely good point, because it enables carbon deposit to be very freely and easily cleaned away without requiring the engine to be completely dismantled as is necessary in the ordinary course of events. The valves are all on one side, and are actuated by a gear-driven cam shaft which is contained inside the crank chamber. Both the exhaust manifold and the inlet pipe are on the same side of the engine, and the latter is fed by a carburettor of extremely simple design. The cooling is on the thermo-syphon principle, and a belt-driven fan to assist the draught through the gilled tube radiator is mounted in front of the engine, where it is driven direct from the crank shaft. The carburettor is adjustable by a milled nut, which projects through the dashboard, and enables the mixture to be altered in richness as required by circumstances.

Not the least interesting feature of the Ford chassis is its unique ignition system. The magneto is of the low-tension type, that is to say, it generates current which is passed to the sparking plugs through the medium of a high-tension coil, which converts the low-tension current into a high-tension discharge at the plugs. The magneto is, however,

of an entirely different type to that which is used on all other cars, for it forms part and parcel of the flywheel.

It is not necessary in a work of this nature to go into the fullest details of this interesting construction, and it suffices, therefore, to say that the same principle as in the ordinary magneto is used, but that the arrangement of the parts is different. The apparatus is extremely simple and reliable. The coils which are used in conjunction with the magneto are mounted on the dashboard within reach of the driver, and are of the trembler type. An interesting point is, that it is possible to use the Ford magneto as a dynamo for the purpose of lighting electric lamps, though this is not recommended by the makers. When, as is quite frequently done, an ordinary high-tension magneto is fitted to the car, the Ford magneto is generally used very efficiently for this purpose. Behind the flywheel, which also contains the magneto as before noted, is the two-speed gear, which is of the epicyclic type, and works upon the principle which has already been described in a previous chapter. When the gears are changed there is no sliding of pinions into mesh, as these are constantly working freely together. There are three trains of meshed pinions, and the action of the gear change is simply to bring one set into use as required. There are two speeds forward and one reverse, all of which are operated by three pedals carried in the sloping footboard in the usual way. The pedal on the right-

hand side applies the foot brake to the counter-shaft, and this member is also incorporated with the gear box. The middle pedal operates the reverse gear, and can be used as a brake in case of emergency. The pedal on the left-hand side acts as a clutch, and also operates the low and high forward gears in conjunction with a hand lever. The latter when placed in a vertical position holds the pedal in such a position that the clutch, which is of the multiple-disc type, is out of action, and it is in this position that the engine runs free. If the driver presses the pedal forward with his foot, he engages the low gear by means of the epicyclic train oı pinions, and conversely if he allows the pedal to come back he engages the high gear, but the high gear cannot be engaged unless the hand lever above referred to is pushed forward. In other words, the hand lever simply acts as a catch to hold the speed pedal in a central neutral position. It, however, performs the secondary function of throwing on the brakes contained in the rear-wheel hub drums, and therefore acts as an ordinary hand-brake lever. It is difficult indeed to imagine any more economical or simple arrangement than this. The control of the engine is effected by two levers placed underneath the steering wheel. These work in ratchet segments, and control respectively the throttle opening and the advance and retard of the magneto. There is no accelerator pedal of the ordinary kind. Behind the epicyclic gear box is a large universal joint contained in a spherical housing, which serves as a

front anchorage of the tube surrounding the propeller shaft. This tube sustains the driving and torque stresses, and is a rigid forward extension of the back axle casing.

Before leaving the engine a word must be said in regard to its lubricating system. This is simplicity itself. The whole of the working parts inside the engine are lubricated on a splash system with the bottom half of the crank chamber serving as a reservoir. The oil, after being splashed on to the cylinders, cam shaft, pistons, gudgeon pins, etc., returns to the reservoir through a filter, and at the same time a certain amount is allowed to pass through the gear box to the propeller shaft and its parts. The flow of oil is maintained by the action of the flywheel, the periphery of which dips into the oil supply and flirts it up into a distributing pipe. Suitable grease cups are mounted on all the points of the chassis that require occasional lubricating. The back axle is remarkably strong and light, and is undoubtedly one of the finest pieces of automobile design that has yet been put on the market. The final drive is by bevel, and a bevel type of differential is also used. It is undoubtedly in a large measure due to the design of this axle that the Ford car is so exceptionally light on tyres. The petrol tank is carried under the front seats, and supplies the carburettor by gravity, the latter being placed low down to ensure a good supply on hills. The springing system of the Ford is, like so many of its other features, quite unique. Instead of the springs being

four in number, and placed lengthways on the chassis, there are only two springs, each half elliptic, and they are placed across the frame immediately above the front and rear axles to which they are suitably articulated. In order to restrain them moving to and fro in front, the front axle is connected to the frame by triangulated radius rods, which ensure that it moves up and down only in a fixed plane, whilst in the rear the combined radius and torque rod provided by the propeller shaft casing acts in exactly the same manner. This type of springing has the advantages of lightness and economy in production, and it certainly produces a very reasonable amount of comfort. Quite a number of cars since the introduction of the Ford have adopted the transverse spring for the front axle, though very few have attempted to use it for the back. Another interesting point is the steering gear. This is carried out by a wheel operating "Ackermann-mounted" front wheels in the usual way, though the ordinary form of worm and sector gear box is dispensed with. The Ford steering is as a matter of fact not irreversible, but the lightness of the vehicle makes this no serious disadvantage. In order to get a geared-down effect, so that the requisite amount of movement of the steering wheel to move the front wheels through a given arc is greater, a small epicyclic gear box is mounted at the top of the steering pillar, where it is very neatly placed so as to be out of the way and submitted to the least possible stress. This gives a geared-

down effect, which makes the Ford steering commendably easy.

In regard to the equipment of the Ford car, it is not to be expected that either as a two-seater or as a four-seater the body-work is of the most luxurious type, but it is at least practical, serviceable, and capable of lasting a very long time, providing reasonable care is taken of it. The equipment includes a double screen, two electric headlights and three acetylene lamps, a hood, and a speedometer. All the details are very well and strongly made. The dimensions of the car are: wheel base 9 feet 4 inches, wheel track 4 feet 8 inches, clearance at lowest point 10 inches, standard wheels are 30 inches in diameter, fitted with 3 inch tyres in front and 3½ inches in the rear. The weight in touring trim is 13¾ cwt. The price of the Ford car as a two-seater is £115, and as a five-seater £125. A landaulet town car is marketed at £175, and in each case the body-work is as standardized as the chassis itself.

The 9·5 *Standard.*—The Standard light car made its appearance amongst the earliest of the light cars which were put on the market, conforming generally to large-car design, and it is one moreover which has been extremely successful in reliability competitions. The chief points of this machine are briefly as follows: A four-cylinder engine, a single-plate clutch, with a very light driving plate giving sweet engagement and making gear change extremely easy, a three-speed gear box with gate

change, a substantial back axle with overhead worm drive, long and easy springing, and carefully designed coach-work.

In regard to the last named, the makers have realized very wisely that however small the chassis may be, the body must of necessity conform to the size of average human beings. The dimensions of the body-work of the 9·5 Standard have, therefore, been based on the requirements of two occupants of rather more than average size. Plenty of leg room is also provided. The frame is of pressed-steel channel section, and is slung fore and aft on long half-elliptic laminated springs. Those in the rear, instead of having the usual link shackles at the tail end, are furnished at this point with double helical spring shock absorbers, which make the riding very comfortable over rough and pot-holed roads. The engine has four cylinders cast *en bloc*, the valves are all on one side, and the cam shaft is driven by silent chain. The bore and stroke are respectively 62 × 90 mm., giving a cubic capacity of 1,088 c.c. Cooling is maintained on the thermo-syphon principle, the water jackets and leads being of generous proportions, as also is the gilled tube radiator. Behind the radiator is a two-bladed fan, driven by belt from the crank shaft, and a notable point in the design of the cooling system is the easy passage for water, which is furnished underneath the valve pockets. The flywheel is fitted with vaned spokes, and as it runs close to a long under shield extending almost to the gear box, it very consider-

ably enhances the draught induced through the radiator, so that the car can be driven for long distances up-hill and in traffic without the least fear of boiling taking place. A Zenith carburettor is fitted, and the inlet passage is cast integral with the cylinders. A short pipe leads up from the carburettor to the centre of this passage, whilst the exhaust manifold is bolted on to the cylinder ports in a neat and easily detachable manner. A particularly interesting and good point in the design of the Standard engine is the fact that the valve chest, which is covered with a quickly detachable plate, accurately fitted so as to retain oil, is in direct communication with the base chamber, so that oil which is splashed about in the latter for the lubrication of the pistons, etc., also is splashed on to the valve stems and guides. These parts, therefore, are constantly and adequately lubricated, and there is no doubt that this arrangement, simple as it is, considerably enhances the quiet and efficient working of the motor, and at the same time reduces wear to a minimum.

The ignition is furnished by a high-tension magneto, driven by the same chain that operates the cam shaft from the front end of the crank shaft. A good point is the fact that adjustment for this chain is provided for in a very simple manner, by means of a plate on the timing gear case, which carries the bearing of the magneto driving spindle. This can be moved laterally, so that the slack of the chain, when this develops in course of time,

can quickly be taken up. The magneto is controlled by a spark advance lever, giving a variable ignition point. Very careful attention has been given to the question of lubrication, a matter which, in connection with a light car engine revolving at very high speeds, is of the utmost importance. Below the crank chamber base is a sump, containing a considerable supply of oil, and attached to the outside of this chamber is a small casing containing an eccentric vane pump driven by the cam shaft. This pump draws oil from the sump through a large filter, and forces it direct to the crank-shaft bearings, and also to two troughs which are cast in the base chamber, and are situated below each outside pair of cylinders. The dippers which catch the oil in these troughs, instead of being as usual carried on the connecting rods, are fitted to the webs of the crank shaft. After being splashed on to the pistons, valve gear, gudgeon pin, etc., the oil runs back into the sump through a strainer of large area, situated between the two before-mentioned troughs, and a certain amount is allowed access to the distribution chain at the front of the crank case. In order that the driver may ascertain that the oiling system is working properly, a small indicator is mounted on the dashboard. Should the hand of this indicator point to "danger," the driver knows that he must stop the engine and replenish the sump with oil. From the motor the drive is taken by a plate clutch to the gear box. This plate clutch consists

of a single disc, carrying a working surface of ferodo, which is held between two metal discs by helical compression springs, which ensure that when the clutch is in action there is no end thrust on the crank shaft or its bearings. The springs which hold the clutch members together are furnished with guide studs, but these do not have to take the drive as larger studs are fitted for this purpose. Provision is made for inserting a little lubricant between the plates should they show any tendency to engage too fiercely. The clutch is operated by a simple toggle arrangement, by a pedal which pushes the inner plate away from the inside of the cover plate against the antagonism of the springs. Behind the clutch is a short shaft, flexibly jointed at each end. This transmits the power to the gear box. The latter provides three speeds forward and a reverse, the changes of ratio being operated by means of a gate lever. The top gear ratio is 4·6 to 1, and the low gear 15 to 1, and a good feature is the fact that on the direct drive, namely, the top gear, the engagement is effected through dog clutches. The propeller shaft which conveys the power to the back axle is of the open variety, and is furnished with a universal joint at each end. In both cases these joints are of the cross-pin type, and of substantial design, and they are carefully encased in spherical metal covers, which contain a supply of lubricant and keep out dust. At the rear of the gear box is the foot brake, which takes the form of two external

shoes furnished with renewable ferodo linings applied to a drum of good diameter. The Standard vehicle is one of the few light cars possessing a counter-shaft brake, which is at once smooth working and very rapid in action.

The back axle is a sturdy piece of work, and contains an overhead worm and a bevel type of differential. Provision is made for easily filling up the casing containing these two components with lubricant. The rear wheel bearings which are carried on extensions of the axle sleeves are adapted to take very heavy side thrusts as well as journal loads. The hand brake operates internally expanding shoes in the rear-wheel hub drums, in accordance with the usual practice. The steering arrangements are on rather uncommon lines. A worm and segment gear is adopted, but instead of the arm being placed in a vertical plane, the box is turned over so that the arm is in a horizontal plane. Furthermore, instead of its being connected to the off-side front wheel, it is connected across the frame to the near-side wheel, which is in turn connected to the former by the usual tie-rod. This arrangement has the advantage of eliminating to a large extent errors in steering, due to the varying angularity of a short steering rod under the action of the springs. The wheels are of the detachable steel type, fitted with 700 × 80 mm. tyres. In connection with the rear axle design, it may be pointed out that the torque and driving stresses are sustained by the front halves of the rear

springs, an arrangement which is found to work very adequately in practice. The wheel base is 7 feet 6 inches, the track 4 feet, and the weight complete with body about 12 cwt. The equipment comprises hood, screens, lamps, and a very well selected and adequate assortment of tools and spare parts. The price of the vehicle is £195, plus a temporary advance of 5 per cent.

The Singer Light Car.—Particular interest attaches to the Singer vehicle for two reasons. First because it was the first of its kind to be put upon the market, and thus to show that it was possible at the price asked for many so-called cycle cars to build a really well-designed vehicle on large car lines, and secondly, because it has always been to the front in competitions. In the Harrogate trials organized by the Royal Automobile Club, a Singer car won the prize for the best all-round performance, and in addition it performed in a very notable manner in the strenuous Austrian Alpine Tour. It has also put up many notable performances on the track, and is altogether one of the most successful light vehicles that has ever been produced. Generally speaking, its design offers but few novel points, but there is at least one important one, namely, that the gear box is combined with the back axle, very considerably simplifying the frame design, and effecting a reduction in weight, though it must be pointed out that this method of construction increases the unsprung weight of the back axle. The frame is, as usual,

of pressed steel, and has a wheel base of 7 feet 6 inches, a wheel track of 3 feet 6 inches, an overall length of 10 feet 6 inches, and an overall width of 5 feet. The engine is supported directly upon it, there being no sub-frame, and has four cylinders, which are cast in pairs. The bore and stroke are 63 × 88 mm., giving a total cubic capacity of 1,096 c.c. The circulation of the water takes place on the thermo-syphon principle, in conjunction with a gilled tube radiator of pleasing design. Behind this is a four-bladed fan, working at a high speed, and driven by belt from the extension of the cam shaft. This fan absorbs very little power, but it practically ensures that no boiling takes place under the most arduous conditions of service. The engine is perhaps the only light-car four-cylinder motor which has its cylinders cast in pairs. This undoubtedly is slightly more expensive, but it has this advantage, that if at any time it is necessary to take the cylinders down, this work is very much facilitated and lightened. The valves are all on the same side, and all interchangeable. They are operated by a cam shaft, which is gear driven, the whole of the distribution gear being contained inside a crank chamber, which has cast aluminium webs extending each side to form a tray between the motor and the frame to which it is attached. The exhaust pipe manifold is bolted on to the cylinders, and the inlet pipe is also external. The carburettor is carried on the side of the engine, opposite to that

on which the valves are placed, and the induction pipe curves over the cylinder castings, its unusual length serving to promote a better atomization of the mixture. The carburettor is a Claudel, and is controlled by an accelerator pedal in conjunction with a lever carried on the steering wheel. The ignition is by a high-tension magneto gear driven from the cam shaft, and furnished with a fixed ignition point. The carburettor is supplied from a tank carried in the scuttle dashboard. The engine is furnished with automatic lubrication, a supply of oil being contained in the sump below the crank chamber, which is forced by means of a direct-acting pump to the three main bearings of the crank shaft, and also to troughs underneath the big ends, whence it is splashed on to all the moving parts. The clutch is a leather-faced cone of the internal type, carried inside the flywheel, which is of large diameter to ensure even running. Immediately behind the clutch is a large universal joint, forming the head of the long propeller shaft, which extends from this point right back to the rear axle.

On joining the latter it is furnished with another enclosed universal joint, which also telescopes to allow for the relative motion caused by the axle being pivoted on the front pins of the rear half-elliptic spring. The back axle is of a particularly ingenious design, as whilst being quite neat and small, it contains as before noted the three-speed and reverse gear box as well as the final trans-

mission. The whole of the gears and the bevel drive are lubricated together through an easily got at oil filler at the back of the axle casing. Change of gear is effected by a gate lever carried in the usual place immediately beside the driver's seat. The selector mechanism is carried on a cross-member level with this lever, and from thence connecting rods operate the gear-striking levers on the axle. The selector mechanism is protected from dust and mud by a metal plate. The rear axle is furnished with a torque member, which relieves the springs of any stress other than that occasioned by supporting the weight of the car and sustaining the drive of the axle. With this form of design it is clear that the counter-shaft brake is not easily arranged for, and therefore both foot and hand brakes are accommodated in the rear-wheel hub drums. Both are of the external expanding type, and are worked through a compensating arrangement, which ensures that both rear wheels receive as nearly as posssible the same braking stress under all conditions. The springing of the Singer car is enhanced by the fitting of enclosed elastic shackle shock absorbers at the rear end of the springs, these serving to account for small irregularities in the road surface. The body-work is extremely neatly designed and well constructed, its handsome lines being emphasized by the fitting of domed mud-guards and valances between the running boards and the body-work. The screen is of the single folding type,

and a neat hood is fitted. At the rear of the body is a large boot for carrying luggage. In addition to the standard model Singer light car, which is priced at £215, a *de luxe* model is also made, differing only from the former in having a complete electric lighting set fitted in place of the oil acetylene lamps. The dynamo is very neatly mounted on the engine, where it is chain-driven from the same shaft which actuates the magneto. This fully equipped model is priced at £225. A coupé model with dynamo is also supplied at £280.

The 15/20 *h.p. Overland.*—This is one of the most successful American cars, and it would be difficult to imagine a vehicle coming at anything like the same price which could be more fully equipped in every possible way. Unlike many other American cars which have sold in considerable quantities in Great Britain, the Overland is a success in its own country, as well as abroad, proof positive of the fact that no precautions have been left undone to make it as practical and satisfactory in its working as its specification is complete on paper. Like many other American machines, the Overland does not pretend to be a racing vehicle. According to European standards, and taking into consideration the dimensions of the engine, it is comparatively slow, but on the other hand it must be borne in mind that the large engine is deliberately never allowed to give its maximum output of power, and therefore long life of the working parts and freedom from falling off in efficiency is ensured, no matter

how carelessly it may be driven by its owner. On the other hand, by the use of a fairly large engine in conjunction with a moderately low-geared ratio, one has a combination which ensures that very good average speeds can be maintained over all sorts of country, without unduly pushing the car when favourable conditions offer. The frame of the car is a straight-through construction of channel-section steel. Upon the front of it the engine is mounted underneath the bonnet, in the accepted manner. A rather unusual feature of the motor is that its four cylinders are each cast separately complete with the water jacket. This enables the cylinders and pistons to be very readily got at for purposes of cleaning when carbonization occurs. The valves are all on one side, and interchangeable, and the whole of the distribution gear which drives the cam shaft is contained inside the upper half of the aluminium crank chamber. The exhaust and inlet manifolds are fitted externally, and the latter supports a Stromberg automatic carburettor. These two manifolds are held in position by four quickly detachable yokes, allowing them to be very easily removed when necessary. The valve guides and springs are not fitted with any cover, but they contain adjustable tappets, and work extremely quietly. The cooling of the engine is carried out on the thermo-syphon principle, the pipes being of very large diameter, and sharply inclined. A gilled radiator of large capacity is used, and behind it is a six-bladed fan, belt driven from the crank shaft. A

ready means is furnished for adjusting the tension of the fan belt to guard against a slip. A Dixie high-tension magneto is fitted, and is carried on the side of the engine opposite to that of the valves, where it is driven through a flexible coupling by gears contained in a casting forming part of the crank shaft. The lubrication is effected in the usual manner, a large supply of oil being carried in the sump, and after filtration forced to troughs under all the bearings, of which there are five to the crank shaft, by a pump driven through screw gearing from the tail end of the cam shaft. A revolving fan indicator on the dashboard shows the correct working of the system to the driver. The bore and stroke of the engine are respectively 101 × 115 mm., and the R.A.C. rating is therefore 25·6 h.p., thus bringing the car into the 6 guinea tax. One of the principal features of the Overland is its equipment, which includes a six-volt Autolite electric lighting and self-starting installation.

The dynamo and the motor for this purpose are separate units; the dynamo is mounted on the near side of the engine and is driven by silent chain, while the motor is mounted on the off side and driven direct on the flywheel by means of gearing, and is automatically thrown out of action when the motor starts. The dynamo gives an adequate supply of current to the accumulators, which are automatically kept fully charged. The control of the engine is effected through an

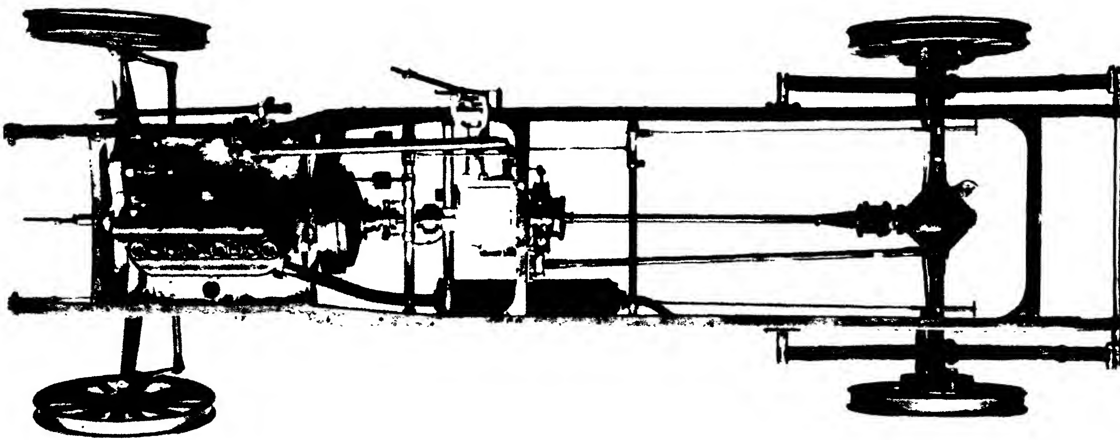
accelerator pedal and throttle, and ignition advance levers are fitted to the steering wheel. The gear box of the Overland car is carried on the back axle, or rather forward extension of the differential casing, and therefore the main universal joint is immediately behind the clutch, which is of the internal leather cone type, mounted inside the flywheel. The back axle assembly is furnished with a long tube, which encloses the propeller shaft, and which at its forward end spreads out into a fork piece, which is supported on bearings mounted on a substantial cross-member immediately behind the clutch. By this means the whole of the driving stress, as well as the torque reaction, is conveyed directly to the frame, leaving the springs free to support the load. The universal joint is thoroughly enclosed in a spherical housing, which contains an adequate supply of lubricant for the pins. Another special feature of the Overland car is the fact that it is furnished with central control. The gear and brake levers, instead of being under the driver's right hand, are in the middle of the car, and are operated by his left hand. At first sight it may seem as though this was somewhat inconvenient, but actually on the road it only takes a few moments for a driver who is used to the more accepted arrangement to become accustomed to this form of control, which has the advantage of doing away with a number of toggle joints, etc., and thus saving a considerable amount of weight,

to say nothing of expense. The three-speed and reverse gear box is operated through a gate lever, and a commendable point in its design is that the shafts, which are mounted on ball-bearings, are very short and stiff. The final drive is by bevel gear, which is completely enclosed in the differential case. The latter is furnished with a large detachable lid, so that it can be easily inspected. This arrangement of the gear box necessitates the placing of both brakes direct on the back wheels. A single drum is used on each hub, and the foot brake consists of internally expanding shoes, working against the internal periphery of this drum, whilst the hand brake contracts bands working on the outside of the same drum. These brakes are very powerful, the drum being of large diameter. The springing in the rear is by three-quarter elliptic springs slung under the axle, and in the front by semi-elliptics. The wheel base is 8 feet 10 inches, and the wheels and tyres are 815 × 105 mm. These are of the quick detachable variety, being furnished with easily demountable rims and a spare rim is supplied. The steering gear is of the worm and sector type, and is furnished with provision for adjustment at all points. The steering wheel itself is 18 inches in diameter. The Overland car at the price of £198 includes a very well designed body, together with a full equipment, including the lighting and self-starting installation already described. The body-work is extremely comfortable, and is furnished with a

one-man hood, and with a wind screen which is adjustable to any position. Quickly attached side curtains are also supplied. The rest of the equipment includes large diameter head lamps and tail lamp, speedometer, electric horn, foot-rest for the rear passengers, rug rail at the back of the front seats, and a full outfit of tools.

2. Cars up to £350

The 12 h.p. Rover.—The 12 h.p. Rover car is a worthy representative of the class which during the last few years has grown deservedly and increasingly popular, and provides a useful mean between the comparatively large and the small light car. The Rover and other vehicles of this type is capable of taking quite luxurious two- and four-seater touring bodies, and where the conditions of work are light may be satisfactorily fitted with a small landaulet. It is reasonably fast, combines tolerably high engine efficiency with quietness and comfort in operation, and at the same time is light on tyres and consumes a comparatively small amount of petrol. The engine is of the four-cylinder type, having a bore and stroke respectively of 75 × 130 mm. It is thus rated by the Treasury formula at 13·9, but no doubt quite easily gives a b.h.p. output of double this figure when accelerated. The four cylinders are cast in one block, and are off-set in relation to the crank shaft, so that when the explosion



PLAN VIEW OF THE 12-H.P. ROVER, SHOWING GENERAL ARRANGEMENT OF THE VARIOUS UNITS IN A STANDARD CHASSIS

occurs above the piston, and the latter is at the top of its stroke, the crank shaft is in the position to convert this energy very rapidly into a turning movement on the flywheel.

The crank shaft is supported on three bronze bearings, which are lined with anti-friction white metal. The valves, which are of the poppet type, are all on the left-hand side of the engine, and are actuated by a single cam shaft, which is driven by a silent chain from the front end of the crank shaft. A second chain serves to drive the high-tension magneto, which supplies current for ignition, and both these chains are enclosed in a weatherproof case, which is kept constantly supplied with lubrication.

The circulation of water is maintained by a water accelerator, in conjunction with a flat radiator fitted with a large number of tubes. The magneto is mounted on a platform cast on to the side of the aluminium crank chamber opposite to the side of the engine on which the valves are placed. On each side of the crank chamber a flat extension of the casting is arranged, so as to form a tray between the chassis frame members and the engine base.

Lubrication of the working parts of the motor is carried out on a simple and efficient plan. The oil supply is contained in the sump below the crank chamber, and a simple gear pump of the pinion type draws oil therefrom, and passes it direct to the main bearings which support the

crank shaft, and also to a series of troughs underneath the big ends, which troughs are kept at a constant level. As the crank shaft turns round, spoons or dippers forming an extension of the connecting rods below the big ends splash the oil out of the troughs over the working parts of the motor, and ensure that a constant stream of lubrication is fed to them, whether the volume of oil in the containing vessel or sump is large or small. The exhaust pipe emerges directly from the water-cooled cylinder casting, and where it is inside the latter is efficiently jacketed with water, which helps to cool the hot exhaust gases and lessen their volume before they are passed to the silencer, thus securing an absence of back pressure with the maximum silencing effect. The inlet pipe is integrally cast into the cylinder block, and the carburettor is clamped on to the side of the cylinder on the side opposite to that on which the valves are fitted.

The fact that the gas passes through a transverse pipe surrounded by the hot-water jacket of the cylinders, ensures the thorough vaporization of the petrol, and also very considerably neatens the appearance of the engine, as no external pipe of any kind is used. The carburettor employed is of the S.U. type, particulars of the principle of which have already been given in an earlier chapter. Suffice it now to say that this carburettor works on an automatic system, whereby the area of the petrol jet, and the amount of air supplied for the mixture, is

varied according to the suction of the engine upon a compensation piston, which again is dependent upon the amount of throttle opening.

The engine control is effected primarily through an accelerator pedal, which operates the throttle, in addition to which there are two levers on the steering wheel, one of which applies to the ignition advance of the magneto, whilst the other serves to set the throttle in such a position that when the accelerator pedal is released and flies back to its limit, the engine is still supplied with a small amount of gas, which keeps it turning over quietly and sweetly.

Attention to the engine is practically reduced to the filling up of the oil tank. For this purpose a strainer and conical-shaped filler are fitted on the side of the crank chamber, and a neat overflow tap is fitted to the sump or oil container in such a way as to prevent the latter being filled too high, which would result in too much lubrication being given to the pistons and cylinder walls and consequently in the engine smoking.

It will be easily understood that if the supply of oil is too great, much of it is wasted by being burnt up inside the combustion chamber, and when this occurs a deposit of carbon is formed on the cylinder walls and piston head, which prevent the proper radiation of heat to the water jacket, and is liable to set up pre-ignition, owing to particles of the carbon becoming incandescent and igniting the mixture before the proper time.

At the rear end of the engine is a flywheel of large diameter, which contains a simple design of single-plate clutch. This is operated in the usual way by a pedal, and is adapted to exercise no end thrust when the clutch is in action. The gear box forms a separate unit to the engine, and is independently suspended from the chassis frame, to which it is attached by two cross-members. This gear box is of the selector type and gives three speeds forward and reverse, the gear changes being operated through a gate lever.

The gate quadrant, and the pivot on which the lever works, are supported directly from the gear box by casing by means of an aluminium extension, instead of being rigidly connected to the chassis frame. This ensures that should a road inequality be met with, which distorted the last named, no strain is imposed on the change-speed gear mechanism, so that gears can always be put in and taken out with perfect facility.

The gear-box shafts run on ball-bearings, and a supply of lubricant in the form of a thick oil or grease is given to the pinions periodically by removing the lid of the gear box which is detachable. Between the clutch, which is entirely closed, and the gear box is fitted a universally jointed coupling shaft, which ensures that all the shafts work perfectly freely, even should the main frame be slightly out of alignment as the result of an accident.

Immediately behind the gear box, and rigidly

supported by it, are two contracting brake shoes, which take effect on a large diameter brake drum attached to a rearward extension of the gear shaft. This brake is operated by a pedal. Contained inside the brake drum is a cardan or universal joint, forming the forward end of an unenclosed propeller shaft, which transmits the power to the back axle through the medium of a second cardan joint.

The back axle, which is worm-driven, is fitted to the rear half-elliptic springs in such a way that the front halves of the latter serve to take the driving thrust from the road wheels, whilst the torque is sustained by a tubular member, which extends forward from the back axle casing, and is attached to the frame cross-member (which supports the gear box) by means of a spring joint. This spring is introduced to prevent any harshness being caused when the clutch is let in quickly and the load has to be taken up rapidly. Since by this arrangement the back axle moves up and down in an arc struck from the pins, to which the forward ends of the road springs are attached, it follows that with this motion the propeller shaft must be provided with some sliding joint to enable it to take up lost motion. Such a joint is embodied in the universal coupling immediately in front of the back axle, this joint being fitted with a leather casing, which allows a certain amount of freedom of movement without permitting the ingress of dust or mud. A filler cap is placed in an accessible position on the differential

casing, so that the back axle lubrication can be replenished from time to time.

The hand brakes take effect direct on the rear-wheel hub drums, and consist of internal expanding metal to metal shoes. These are operated through a balance gear or compensating lever, which ensures that an equal pressure, and therefore an equal amount of friction, is imparted to both wheels when it is desired to pull the car up quickly. Most of the braking is, of course, done on the foot brake, which being on the propeller shaft has its own balancing gear in the differential axle.

The 12 h.p. Rover car is sold complete either in the two-seater or four-seater form, the body-work being notable for its comfort and the excellent quality of its finish. In the equipment of the car a complete electric lighting outfit is included, and consists of a 12 volt Rotax dynamo, which supplies a set of batteries, which in turn gives current for two head-lights, two side lamps, and a tail lamp. Detachable artillery wheels, with a spare wheel, are also part of the standard equipment, which includes a cape cart hood and a single wind screen. The wheel base of the Rover car is 9 feet 8 inches, the track 4 feet 2 inches, and the length over all 14 feet. The weight of the chassis is 14 cwt., and that of the complete car approximately 22 cwt. The space available for body-work is 7 feet 2 inches. The maximum speed is round about 50 m.p.h.

The price of the two-seater is £331 and of the

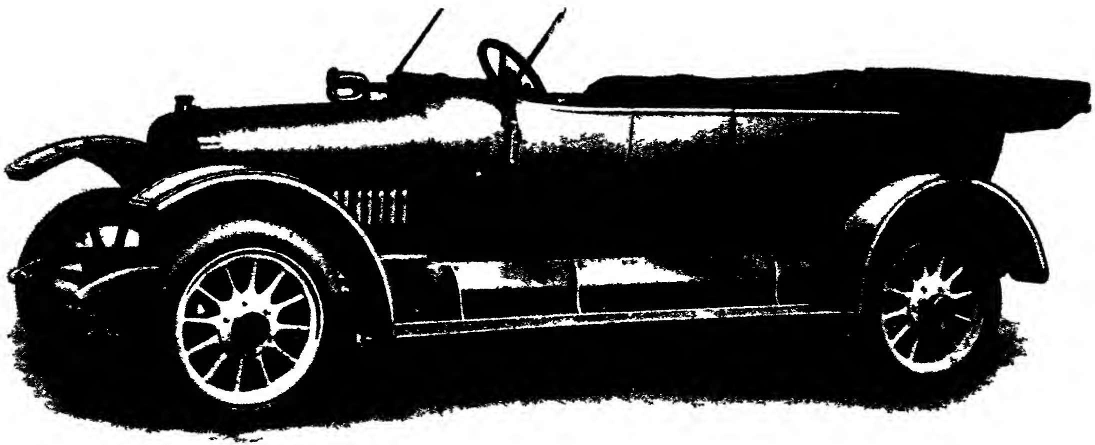
four-seater £350. There is also a coupé model for £425 and a landaulette at £475.

3. Cars up to £400

The 16 h.p. Sunbeam.—The 16 h.p. Sunbeam is particularly interesting, because it attained spontaneous success immediately it was put on the market, and also because its design and construction are largely the outcome of a strenuous and deliberately upheld racing policy. Before dealing with the touring car it may be as well to point out that Sunbeam racing cars, which were only specialized editions of the standard 16 h.p. model, attained a sweeping success in the 1912 Grand Prix Race, held in France, when it finished first, second, and third in the large class limited to vehicles of 3 litres' capacity. Since then a Sunbeam car has won the British Tourist Trophy Race, held in the Isle of Man, and various models have accounted for a large number of international records set up at Brooklands. Although the 16 h.p. Sunbeam car is only one of three models, one may say that in this case one sees the results of specialization as carried out in the British manner, for practically no alterations of any note have been made in the chassis during the last two or three years, except in regard to small details, some variation in the design of which has been dictated by lessons learnt in racing. One of the principal features of the 16 h.p. Sunbeam engine is that it belongs to the long-stroke class.

The bore is 80 mm. and the stroke 150, so that although it is rated at 15·9 in the R.A.C. formula, it is easily capable of giving something like three times this power when fully accelerated. In fact, the racing models of this engine, which only differ from the standard in having more lift to the valve, a slightly higher compression, and lighter reciprocating parts, have been made to give over 80 h.p. on the brake. In spite of this large output of power the Sunbeam engine is nevertheless pleasingly docile and easily controllable, and it does its work with an absence of harshness that is fine testimony to the excellence of design and material employed in it.

The cylinders are cast *mono bloc*, and have their axis off-set in relation to the crank shaft, so that full advantage is made of the turning effort when the piston is at the top of the stroke. They are completely water-jacketed, and the cooling water is circulated by means of a rotary centrifugal pump. This is driven by the right-hand end of a cross-shaft, which is set athwart the cam shaft, and driven by it through the medium of screw gearing. The other end of the same shaft drives the high-tension magneto, which is furnished with an advance and retard lever. The cam shaft, which is contained in the crank chamber, and supported on ball-bearings, is driven by a silent chain, and the cams are cut solid in the shaft itself. The valves are side by side and of the same size. They are covered in with detachable aluminium dust-proof panels and



THE 16 H P SUNBEAM CAR A TYPE WHICH HAS DONE MUCH TO MAKE MOTORING HISTORY ALL OVER THE WORLD

are furnished with adjustable tappets. A rather unique point of the Sunbeam design is that the valves are inclined in relation to the cylinder, thus slightly reducing the area of the combustion chamber, and so helping to promote the thermal efficiency of the engine to an appreciable extent. The top half of the aluminium crank chamber carries the whole of the mechanism of the engine, the bearings supporting the crank shaft being firmly bolted to it. The bottom half merely acts as an oil well. In order to simplify the construction of the motor, the oil ducts used in conjunction with the forced-feed oiling system are cast integrally into the crank chamber itself, so that external pipes are done away with. The crank shaft is of selected high tensile steel, with a bearing between each throw. The connecting rods are of H-section steel and their big ends are lined with white metal. The pistons are specially lightened, so as to give smooth working, at the same time allowing very high rates of revolution to be attained with the minimum of vibration. They are fitted with three rings, and are made in such a manner as to obviate any warping due to the accumulation of heat. A complete system of forced-feed lubrication is employed. Immersed in the oil carried in the sump, which forms the bottom of the crank chamber, is a gear-driven oil pump, which sucks the lubricant through a filter from the containing vessel and forces it to the main crank-shaft bearings through a series of ducts. From thence it passes through the hollow crank shaft to

the big end bearings, from which it exudes in the form of a fine spray, which is thrown on to the pistons, gudgeon pin, cam shaft, and distribution gear. An oil indicator to show the proper working of the system is mounted on the dashboard, and consists of a small plunger, which is forced up by the pressure of the oil against the action of a spring.

The carburettor is a Claudel, and is clamped direct on to a flange cast on the side of the engine opposite to that on which the valves are situated. The inlet pipe is entirely enclosed inside the motor casting, so that it is thoroughly jacketed. The petrol tank is attached to the rear end of the frame, and supplies the carburettor by air pressure, this being furnished by a positive air pump mounted on the side of the crank chamber and operated by the cam shaft. In order to keep the motor as cool as possible, the exhaust manifold, which is bolted on to the cylinder casting, is furnished with deep radiating flanges, and there is a belt-driven fan placed immediately behind the honeycomb radiator. The clutch is of the leather to metal cone type, and is completely enclosed in the flywheel. It is particularly efficient and simple in design. A number of small springs are fitted under the leather lining, which give it an exceedingly smooth and progressive engagement. It is easily adjusted by hand, and is fitted in such a manner that no end thrust is put on either the engine or the gear bearings when the clutch is in engagement. A short flexibly jointed shaft furnished with a quickly detachable

coupling piece leads from the clutch to the gear box. The latter is suspended at three points to the cross-members of the frame, so that any distortion of the last named does not affect the alignment of the gear-box shafts themselves. These are as short as possible, so as to be free from whip, and are mounted on large diameter ball-bearings. Four speeds forward and a reverse are provided, and these are operated by a change-speed lever working in a gate quadrant. A safety catch is provided to prevent the gear being put into reverse inadvertently. The gear box is exceptionally strong, as the whole of the aluminium casing is a single casting with the exception of the lid, and it is thus perfectly oil proof. Immediately behind the gear box is a foot-operated counter-shaft brake. This is of very large diameter, and is of the internal expanding shoe type. The drum against which the surfaces take action has a series of radiator ribs turned in its outer periphery, so as to get rid of the heat of friction as quickly as possible. The shoes are expanded by a cam arrangement, the shaft of which is mounted in the gear box, and a complete adjustment is provided so that all wear can be rapidly taken up. Inside the brake drum is the housing for the main universal joint at the head end of the propeller shaft. There is another universal joint at the tail end, and the shaft is of the open type. At the tail end also there is a plunging or telescopic joint, so that all the strain, except the driving torque, is relieved from the propeller shaft and its bearings. Both these

universal joints are thoroughly enclosed in metal oil-retaining cases.

The rear axle or differential case containing the bevel gear, differential gear box, and live axle is a malleable casting, into which are pressed strong steel tubes, which extend sideways and take the bearings of the road wheels. The driving shafts are thus only exposed to the strain of rotating the wheels, and not of supporting the load of the car. Heavy ball-bearings are used throughout. The torque reaction of the back axle is taken by a special torque member spring-supported from one of the cross-members of the frame, whilst the driving thrust is sustained by the forward half of the rear springs. These latter are of the three-quarter elliptic type, and incorporate a large number of leaves. The steering is by worm and sector, and all parts subject to wear are provided with a simple form of adjustment. The road wheels are shod with 815 × 105 mm. tyres, and are of the Sunbeam detachable type. All are interchangeable, and the self-locking device used for holding them on the hubs is very simple and efficient. The control of the car is effected by an accelerator pedal and by throttle and ignition levers on the steering-wheel, also by the usual clutch and brake pedals and hand-brake lever.

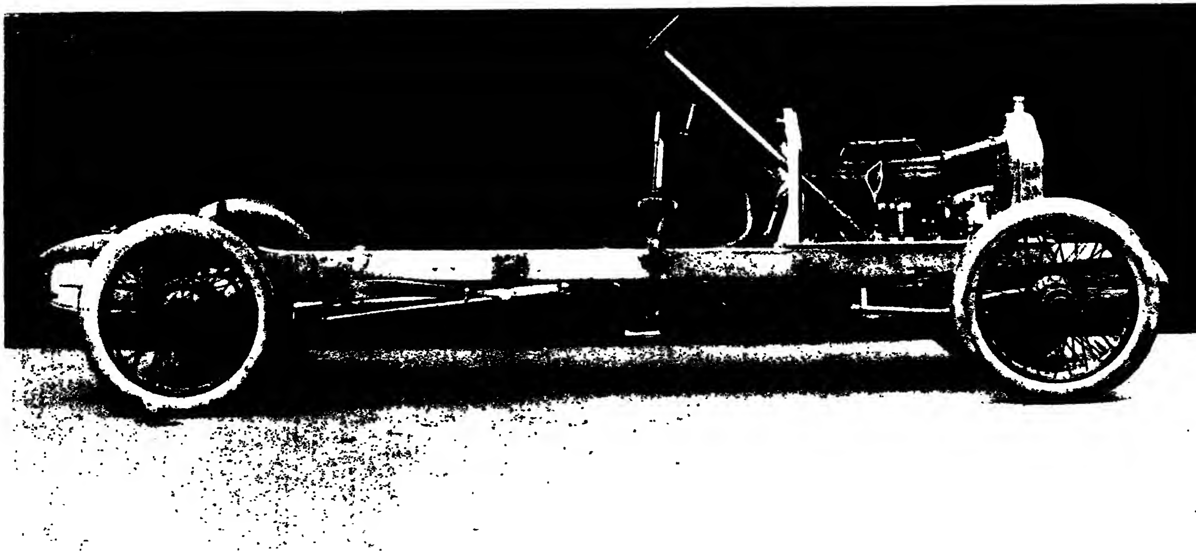
A special feature of the Sunbeam car is the body-work fitted to it as a standard. This is built throughout in the Sunbeam Company's own works, and represents a step forward in carosserie design.

One important point is, that the front seats are adjustable fore and aft, so that drivers of different heights can equally well be suited. This is controlled by a screw action, which is quite easy to work. The one-man hood, which can be erected or closed down in a few moments, instead of being mounted on a framework of wooden sticks, is built up on a base of light steel tubes, which are stronger and at the same time lighter and of more pleasing appearance. The price of the Sunbeam chassis complete with mud-guards and detachable wheels is £385.

4. Cars up to £550

The 16/20 *Wolseley.*—It would be difficult to select a better representative of British design as applied to the 90 mm. or 20 h.p. type of car than is offered by the 16/20 Wolseley, the product of the largest motor manufacturing concern in the British Isles, and moreover one that has been associated with the automobile industry since its very inception. The 16/20 Wolseley is undoubtedly an extremely popular car, because it strikes a happy medium which is suitable for all kinds of work. Whilst not too heavy for a comfortably luxurious two-seater, the chassis is equally well-fitted to carry a moderate-sized limousine. Moreover, it is reasonably fast, a sound hill-climber, quiet in running and easy to handle, and of the utmost proved reliability. To the vast majority

of the motoring community these qualities appeal more strongly than mere speed, and it is obvious that the object of the Wolseley designers has been to obtain the greatest possible luxury in road travel consistent with the production of a car at a moderate price. A rather interesting feature about the Wolseley car is that it is from first to last practically the product of a single firm, as the steel incorporated in the chassis construction is manufactured by Messrs. Vickers, Ltd., who are the proprietors of the Wolseley Motors, Ltd. The frame is, of course, of pressed steel, and a feature of its design is that it is practically straight throughout, there being only a slight insweeping of the front to give a good steering lock and a small rise at the rear to carry the frame over the axle. This construction simplifies the fitting of the body-work and promotes great strength. The engine is mounted on the frame direct, and the axis of the crank shaft is inclined downwards towards the rear, so that when the car is loaded there is a straight line drive from the engine to the back axle, thus reducing to a minimum the work of the universal joints and tending to increase the all-round efficiency of the transmission. The engine, the bore and stroke of which are 90 × 121 mm., has its cylinders cast in pairs. The circulation of water through the jackets is effected by a pump, which, together with the magneto, is placed at the side of the engine, where it is driven by chain from the chain-driven



SIDE-VIEW OF THE 16-20 H.P. WOLSELEY CHASSIS

cam shaft. The latter operates the valves, all of which are of the same size and on one side of the motor. They are fitted with adjustable tappets, so that the clearance between the valve stem and the cam can be regulated to take up wear, and the whole of the mechanism is enclosed by detachable aluminium panels, which render it dust-proof. The exhaust and inlet pipes are separate to the motor, and are fixed on by an arrangement of simple stirrups, which make them readily detachable. The inlet pipe itself is double branched, the branch to each pair of cylinders being cast integrally with the water jackets. The carburettor is of the S.U. type, manufactured under licence by the Wolseley Company. Behind the honeycomb radiator is a large fan driven by belt from an extension of the shaft which actuates the magneto and water pump. The arrangements for lubricating the engine are very thorough, the action being entirely automatic. The engine base forms a reservoir for the oil supply, and bridging this reservoir are narrow troughs into which splash the dippers on the connecting rods. The main bearings of the crank shaft, which are three in number, also have troughs formed over them. These are directly fed with oil under pressure, and a further branch pipe delivers oil on to the cam shaft and magneto chains contained in the aluminium housing at the front end of the engine. The circulation of oil is effected by a rotary pump driven through skew gearing from the cam shaft,

and mounted on the side of the engine. This draws oil from the reservoir through a gauze strainer, and delivers it to the distribution pipes, and also to an oil drip indicator mounted on the dashboard. When the engine is running, a continuous stream of oil is visible through a small window. A drain plug is fitted in the crank chamber, so that the oil reservoir can easily be emptied, whilst for replenishing with lubricant a filler with a gauze strainer is provided on the side of the engine in an accessible position. Sufficient oil is carried to last from three to four hundred miles. Carried on the side of the engine, and driven direct through a special cam on the cam shaft, is a small positive air pump, which provides pressure for the petrol supply, which is fed to the carburettor from a tank carried at the rear of the chassis. The clutch is of the multiple-disc type, with metal to metal surfaces running in oil, and is entirely contained in the flywheel. It exercises no end thrust when conveying the drive. Immediately behind it is a universally jointed shaft, transmitting the power to a gear box, which provides four forward speeds and one reverse, the fourth speed being a direct drive. This gear box is supported by two cross-members, which sustain it on three points, so that frame distortions are not communicated to its shafts. A clutch stop, which slows down the revolving discs when the clutch is disengaged, facilitates gear changing; this is effected by the usual form of gate lever with a

safety catch to prevent the driver accidentally getting into reverse gear. The whole of the selector mechanism is enclosed inside the gear box itself, all the shafts of which are short and stiff, and run on ball and roller bearings.

Immediately behind the gear box is the foot brake. This is a very powerful affair of the locomotive type, consisting of two contracting shoes operating on the periphery of a drum fitted to the gear-box counter-shaft. This brake works equally well whether the car is running backwards or forwards, and is furnished with a means of adjustment at all points, so that any slack due to wear can quickly be taken up. The brake drum carries at its rearmost side a globular housing containing the main universal joint, which is of the cross-pin type, and thoroughly protected against the ingress of dust and mud. The cardan shaft is open, and terminates at its rear end in a combined universal and telescopic joint, which like the upper joint is entirely cased in with an oil-retaining cover. Worm drive is used for the final transmission, the worm being placed underneath the differential so as to ensure perfect lubrication under all conditions. Its casing is provided with an easily got at lubricant filler, and there is also a large inspection cover at the top of the differential case. Steel tubes which form side extensions of the differential casing carry the bearings on which the road wheels revolve, the internal driving shafts being submitted to none of the strain of carrying the weight of the car, but

only to a torsional stress. The driving thrust from the axle is conveyed to the chassis through the front portion of the rear cantilever springs, whilst the torque reaction is taken by an articulated arm, which proceeds forward from the differential casing, and is pivotted in the front to the main cross-member of the frame, which supports the gear box. This torque rod relieves the springs and the universal joints of any strain when the car is being started. The suspension is in front by half-elliptic and in the rear by cantilever springs. A special feature in this connection is that the pivot blocks of the springs are connected together by a rod which proceeds transversally across the frame from one to the other. The idea of this system is to prevent rolling, which it is claimed to do very effectually. Special attention is devoted to the lubrication of all the shackles. The front axle is an H-section girder of great robustness, and the stub axles are, although neatly designed, extremely strong. The steering is of the worm and segment type, and means are provided for taking up any wear that may occur. Both in the front wheels and in the rear Timken roller bearings are used, which are capable of withstanding a lateral thrust as well as a journal load, and they are also adjustable. The rear brakes, operated by hand, are of the internal expanding variety, consisting of double-acting shoes, which are expanded inside the rear-wheel hub drums. These are actuated through rods provided with a compensating mechanism by

a hand lever carried immediately beside the gear-change lever. The steering wheel is fitted with hand ignition and throttle levers. A particular feature of the Wolseley chassis is the fact that it is furnished with a very sturdy aluminium dash-board, which helps to rigidify the frame, and which certainly contributes very much to the appearance of the finished car. This aluminium dashboard supports the instruments, such as the oil indicator, the air-pressure gauge, the electric light switch-board, etc., and also acts as a stiffening bracket for the steering pillar. The chassis is turned out complete with an electric dynamo, switchboard and battery, ready wired for the application of the usual head, side, and tail lamps. The dynamo is mounted at the side of the clutch shaft, and is driven by belt from a pulley mounted on the clutch casing, so that it is at once out of the way and quite easily get-at-able. The wheels are of the Rudge Whitworth detachable wire pattern, fitted with 815 × 105 mm. tyres for cars with open bodies and 820 × 120 mm. for cars with closed bodies. The dimensions of the chassis are 11 feet 1 inch, the track 4 feet 6 inches, the overall length 14 feet 10 inches, and the overall width 5 feet 7 inches. The range of speed on the top gear, on the level, is from 7 to 45 m.p.h., though various rear-axle ratios are fitted up to suit different types of body. The 16/20 Wolseley chassis can be equipped at a small extra charge with an electric starter. This starter is of the same make as, and is worked in conjunction with,

the lighting system. The starter operates by a friction contact with the periphery of the flywheel, the control being by pedal.

The price of the standard 16/20 Wolseley car complete with body, hood and screen, horn and full kit of tools, and fitted with electric lighting equipment, and detachable wheels with tyres, is £520.

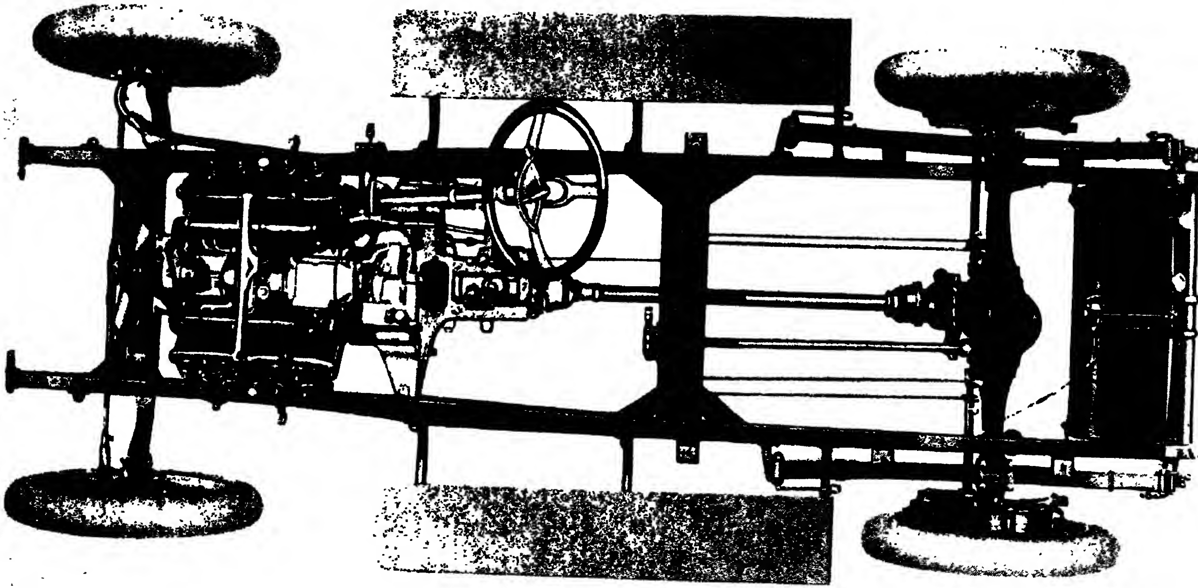
The 25 h.p. Vauxhall.—This is another good type of general utility car, slightly larger than the Wolseley model previously dealt with. It has established a great success as a weight-carrying chassis with remarkable powers of acceleration, and notable for hill-climbing and silent running on the top gear. In a modified form, and with the same engine dimensions, a sporting type model of the same size is made, and known as the Prince Henry type. This, it will be remembered, was one of the first British cars to participate in the Prince Henry tour. We propose, however, to deal only with the standard model. The frame is of pressed steel, cambered over the rear axle to facilitate the use of low side doors to the body-work, and inswept forward of the dashboard, so as to admit of the widest possible steering lock. The springs upon which it is hung are of the semi-elliptic type all round, and are of good length, and fitted with a large number of leaves. The engine, the dimensions of which are 95 × 140, has its cylinders cast *mono bloc*, thus securing the maximum rigidity, and ideal conditions for the thermo-syphon cooling, which can take

place freely should the pump circulation fail from any cause. A notable feature of the engine is its clean design, coupled with a very ready accessibility of all parts. The valves are all disposed on the left-hand side of the engine, and their tappets and springs are encased by two detachable aluminium panels. The front cross-member of the frame is so dropped that the cam shaft with its bearings may be readily withdrawn for inspection without disturbing more than a minimum number of parts. Cooling is on the thermo-syphon principle, in conjunction with a honeycomb radiator of characteristic design. Behind the latter is an eight-bladed fan of large diameter, driven by belt from the magneto shaft. The cam shaft is chain-driven, and the same chain operates the high-tension magneto. This is mounted on the same side of the engine as the valves, with the accessibility of which, however, it does not interfere. The carburettor is a White and Poppe, bolted direct on to the cylinder casting, on the side opposite to the valves, a special feature of the Vauxhall design being that the induction pipe is contained almost wholly in the cylinder casting, and consequently is kept thoroughly warm, with a considerable gain in respect of acceleration and petrol economy, through the mixture being better atomized. The water circulation pump above referred to, instead of being mounted on the side of the engine, forms practically an integral part of the cylinder casting, and is driven by the same belt which operates the cooling fan. The

crank case is an aluminium casting, and supports the entire weight of the crank shaft on five bearings, which are of white metal. The lower portion of the crank chamber merely acts as an oil reservoir. The whole of the crank-shaft bearings can be readily inspected by removing two aluminium doors in the side of the crank case. Very strong claims are made for the efficiency, reliability, and economy of the Vauxhall lubrication system. A supply of oil is carried in the sump. A plunger pump, driven by a ball-bearing eccentric on the rear end of the cam shaft, dips into a filter chamber in the oil sump, and draws up oil, which is forced through a series of branch pipes to the main crank-shaft bearings, and thence through the hollow crank shaft to the connecting-rod big ends. The entire pump and its valves can be readily detached from the motor. A gauge on the dashboard indicates the pressure of the lubrication system, and the level of the oil in the sump is indicated by a float fitted at the rear end of the crank case. After its journey round the circuit the lubricating oil returns into the sump, is filtered and pumped round again. The filter is in the form of a tray with a gauze bottom, and may be withdrawn from the front of the engine for purposes of cleaning. Forming part of the oil pump is an air-pressure pump, which keeps up pressure for the supply of petrol to the carburettor from the tank at the rear of the chassis. The whole of the engine and gear box is mounted on a sub-frame, which makes all of the parts very accessible. The clutch

is of the multiple-disc type, combined with the flywheel. It can easily be dismantled without disturbing either the engine or the gear box. The latter provides four forward speeds and a reverse, with a direct drive on top. The pinions are so arranged that the reverse gear is out of mesh while the forward ratios are engaged. All the shafts are carried on ball-bearings, and the pinions are mounted on castellations. The clutch shaft is furnished with flexible couplings. Behind the gear box is a large internal expanding brake, the drum of which serves to carry the outer part of the main universal joint. Adjustments are provided at all points of the brake mechanism. The transmission is by an open propeller shaft to a bevel-driven back axle, this shaft being universally jointed at each end. A separate torque member is provided to sustain the reaction of the axle under a driving stress, whilst the thrust is transmitted through the forward part of the half-elliptic springs. The steering gear is adapted to require a minimum of effort on the part of the driver, and the worm gear is completely circular so that when wear takes place fresh surfaces can be offered to the worm pinion. The rear brakes are like the counter-shaft brake, of the internal expanding type, and are operated through rods supported on knuckles, which prevent whip occurring. The dashboard is of aluminium. The price of the Vauxhall 25 h.p. chassis is £545, including dynamo lighting set, engine starter, five wheels and five tyres, speedometer, watch and two number plates.

The Cadillac Car.—Few developments in automobile design during recent years have been more interesting—or more sudden—than the tendency which some American constructors have exhibited for the multiplication of cylinders. Hitherto they, perhaps more than any European makers, have specialized almost exclusively on the four-cylinder engine, and except in a few cases their attempts to make "sixes" have not been altogether successful. At the same time the standard of luxury in America is as high, if not higher, than it is elsewhere, and their manufacturers have not been unaware of the demand that has sprung up for "something better." This has crystallized into the production of eight-cylinder vehicles in some little quantity, and there is more than a little likelihood that before long there will be some examples of the twelve-cylinder engines on the market. This type has, of course, been used with considerable success by the Sunbeam Company in a racing machine, but hitherto has been confined otherwise to aeronautic work. This eight-cylinder proposition is particularly interesting. De Dion Bouton have for some time made two distinct eight-cylinder models, and at the beginning of the war Metallurgique, Ltd., also were making one of this type, but the first car in America to embrace this principle was the Cadillac. This make has always been a favoured one in this country; and it is perhaps not too much to say that the Cadillac more than any other American car



PLAN VIEW OF THE NEW EIGHT-CYLINDER CADILLAC CHASSIS

caused European engineers to realize that, when they chose do so, the United States could make a fine car and one that admitted no superior in point of reliability and completeness. As a matter of fact the Cadillac was the first automobile to come over to Europe completely equipped with an efficient self-starting and electric lighting outfit, and it has indeed been twice awarded by the Royal Automobile Club that blue ribbon of the motoring world—namely, the Dewar Trophy—an award which is given to that which represents the highest automobile progress in current design.

The general lay-out of the chassis conforms to standard in every respect, the frame being of the deep-section pressed-steel type. The engine consists of two pairs of *mono bloc* cylinder castings, four in each block. These are mounted on the crank-case at an angle of ninety degrees with one another, and the water jackets are cast integral with the cylinders. This in itself is a notable departure for the Cadillac design, as hitherto the cylinders have been separate and fitted with spun copper water jackets. A single cam shaft, driven by silent chain from the crank shaft, actuates all the sixteen valves, which are placed opposite to one another. The inlet pipe is integral with the cylinder casting, but the exhaust manifold is bolted on externally. The circulation of water is maintained separately through each block, there being two water pumps, carried at either end of a cross-shaft in the front of the engine, which is driven

through skew gearing direct from the crank shaft. A particularly good point in the construction of the cylinders is that each has a detachable plug in the head, which enables carbon deposit to be very easily removed when necessary. The whole of the valve mechanism is neatly enclosed against the ingress of dust, etc., and the only disadvantage about it is that owing to the valves being close together and facing one another, also to the presence of other gear in between them, they are not by any means accessible. This, however, is more or less unavoidable with the eight-cylinder type of engine.

A forced-feed lubricating system is adopted, and the pump for this purpose located at the front of the crank-case. It draws lubricant from the crank-case and delivers it under pressure to the main bearings and also to the connecting rod bearings. A separate feed is also provided to the cam shaft, and the remainder of the motion, such as pistons, gudgeon pins, etc., are attended to, the excess of oil which comes from the bearings being hurled on to them. An interesting point in connection with the pistons is that multiple rings are fitted, that is to say, there are three rings in each groove, and these rings are pinned together to prevent individual rotation so that their slits never come opposite one another.

The engine is fitted with a complete lighting, starting, and ignition installation. This is effected by a combined electrical machine, which is

mounted on the right-hand side of the engine crank chamber. It acts both as a motor and a dynamo, and rotates the crank shaft through a rack cut in the rim of the flywheel, into which a pinion is brought into mesh upon pressing a starting button mounted on a dashboard, and also pushing the clutch pedal out of engagement. When the button is pressed, the armature of the motor generator turns very slowly, and this enables the gear pinion to mesh with the gear teeth and the flywheel. When the clutch pedal is pressed right out, the full power is applied, and the motor is rapidly started up. Upon releasing the clutch a solenoid is disengaged, which throws over a switch, the effect of which is immediately to convert the motor into a dynamo, which charges the batteries, and through them supplies current for the lamps and the secondary ignition. This is of the dual kind, worked in conjunction with a single high-tension distributor. Up to about 300 r.p.m. of the engine the ignition current comes from the storage battery. Above that speed it comes from the generator, this function being performed entirely automatically, so that a fat spark is assured at the very lowest engine speeds. It is claimed that this system has considerable advantages, therefore, over the ordinary high-tension magneto. An auxiliary ignition circuit is furnished by six dry cells, and these are used for starting and emergency. The automatic spark advance is another feature which characterizes the ignition system of the Cadillac. This is accom-

plished by means of a governor device, which alters the timing of the ignition in relation to the speed of the engine. The faster the motor turns, the further advanced is the spark, so that the best conditions of driving are always fulfilled without any attention on the part of the man at the wheel, and at the same time maximum efficiency is ensured at all times. A hand-controlled spark advance lever is also mounted on the steering wheel.

In regard to the lighting equipment, one of the great problems solved in this system is the control of the voltage and the amount of current which is generated under varying engine speeds and in varying conditions of the battery. A very ingenious form of regulator automatically governs the charging rate to the battery and the voltage of the current to the lights. The more nearly the battery is discharged, the higher is the charging rate, and this rate gradually decreases as the charge in the battery increases. The storage battery has a capacity of 130 ampere-hours, and when that has been reached the charging practically ceases. The regulator is furnished with an ingenious indicator, from which a reading of the amount of energy at any time stored in the battery can be made. The whole of this combined starting, lighting, and ignition mechanism, although apparently complicated, takes up very little space, and is almost entirely enclosed. It is wonderfully reliable, and as everything possible is done automatically, no attention is required.

The rear end of the crank chamber contains the flywheel and clutch, and terminates in an extension which encloses the three-speed gear box. The latter and the motor are thus braced together in one unit. The clutch is of the multiple-disc type, an unusual feature being that the alternate plates are faced with an asbestos material. Central control is fitted, that is to say the gear and hand brake levers are in the middle of the car and spring directly from the gear box. A great advantage of this system is, of course, that an easy entrance on the driver's side is not interfered with. To further facilitate this, the steering wheel is centrally hinged so that it can be tilted out of the way.

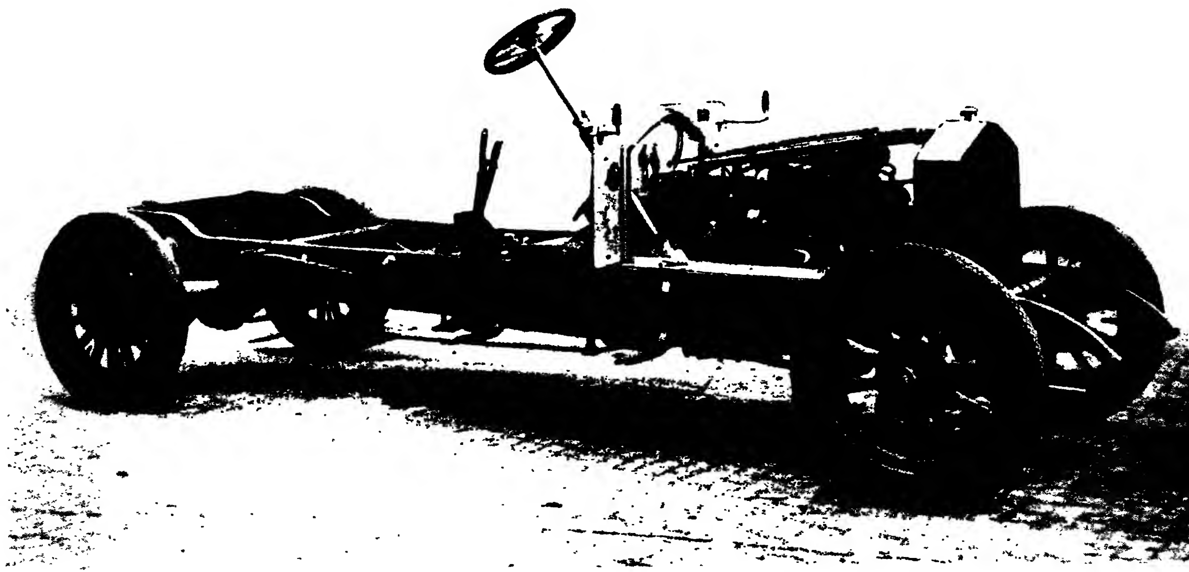
The arrangements for control, clutch, and brake pedals, etc., are of the usual kind.

Transmission is by means of an unenclosed propellor shaft and bevel-driven live axle. This is suspended by half-elliptic springs, and both brakes take direct effect on the rear wheels, one being internal expanding shoes and the other external contracting bands.

Fuel is contained in a tank at the rear of the chassis and is pressure fed by means of a direct-acting pump. A small feature of the Cadillac which is worthy of note is that a power-driven tyre pump —two-cylinder—is a permanent attachment to the engine. The wheel base is 10 foot 2 inches, the tread 4 foot 8 inches. The car is made in several models (7-passenger, touring, salon, 3-seater), the price being £495.

5. Luxury Cars

1. *Rolls-Royce.* — The Rolls-Royce car has achieved such an extraordinary reputation that it is almost unnecessary to touch upon it, though mention should be made of its remarkable performance in the conquest of the Alps for two years in succession, and of its fifteen thousand miles' reliability trial under the auspices of the Royal Automobile Club in 1907. The whole of this distance, which was run continuously day and night, only involved one involuntary stop of thirty seconds' duration to turn on the petrol tap, and it was thus the longest official non-stop run on the road that has ever been accomplished. There is probably no car in the world made with such extreme care as the Rolls-Royce, and the results which are attained by this meticulous attention to all details are a source of pride to every Englishman, for it is acknowledged throughout the world, if only on account of this one car, that the home industry makes the finest motor vehicle that has ever been seen. As much time and attention are spent in the Rolls-Royce works in testing and eliminating small noises, as most firms would apply to the making of a complete car. There is the special testing track at the works, where every chassis is put through its paces at various stages of its last touches, and in addition each engine is submitted to an individual test on the bench, which is of so



A "LUXURY CAR" *PAR EXCELLENCE.* THE NOTABLE ROLLS ROYCE CHASSIS

strenuous a nature that any weakness must be discovered. In like manner each gear box is individually tried out on a special testing apparatus, and is not allowed to be passed into the erecting shop until it has passed through many tests, including especially one of noise. The back axle gears are tested separately also in a special machine, and are required to attain a certain degree of silence before they are allowed to be fitted to a chassis. The engine is a six-cylinder, with a bore and stroke of $4\frac{1}{2} \times 4\frac{3}{4}$ inches. It develops approximately 48 h.p. at 1,200 r.p.m. The cylinders are cast in two units of three cylinders in each. The whole of the engine is attached to the chassis by a special form of suspension, so that the strains to which the frame is subjected from road shocks are not transmitted to the engine casing. The crank shaft is of an exceptionally large diameter, and is carried on seven bearings, the areas of which are very large, and this fact, combined with the special system of forced lubrication, makes wear almost imperceptible. The crank shaft is hollow, and combines lightness with strength. The engine is lubricated by a forced feed system of great completeness. There is no splash whatever, and consequently a smoky exhaust is virtually impossible. There is a large sump beneath the crank chamber carrying the main supply of lubricant, and in addition a further supply is kept in a tank attached to the side of the chassis, from which the sump can be from time to time replenished in case of need. The oil is

pumped through the hollow crank shaft to the big end and main crank-shaft bearings, and up the connecting rods to the gudgeon pins and pistons, so that whatever the speed of the engine, a film of oil is maintained by constant pressure between the bearing surfaces of all working parts.

A special feature of the Rolls-Royce lubrication system is that when the accelerator pedal is operated and the throttle thereby opened, an additional lubrication supply comes into operation, and extra oil is injected directly on to the cylinder walls at the thrust side of the pistons. By this means the supply of oil is, as it should be, roughly proportional to the load on the engine; thus at no time is the engine starved or overfed with lubricant. There are two entirely separate systems of ignition, which work independently of one another with two separate sets of sparking plugs, although both are operated by the same ignition lever mounted on the steering wheel. One system of ignition consists in the ordinary high-tension magneto, whilst the other is a synchronized high-tension system, employing a special coil and two independent sets of accumulators being provided.

This system has been adopted because of its extreme simplicity and the ease it offers in restarting the engine, which if warm can easily be done by merely turning a switch without the necessity of the driver leaving his seat. The distributor for the accumulator ignition is fixed on the front of the

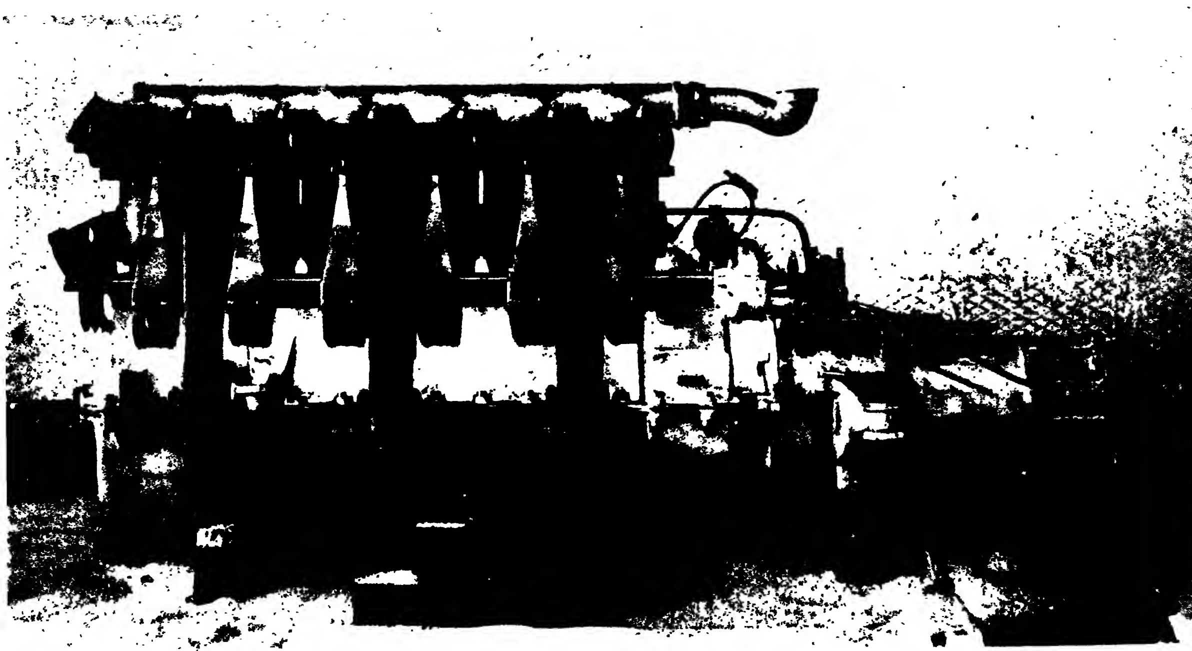
engine in an accessible position, and also embodies the primary make and break of the battery current. The induction coil is manufactured by Rolls-Royce, Ltd., themselves, and is mounted on the dashboard under the bonnet. It will be noted that in the case of the Rolls-Royce the system of ignition allows of either the magneto or the accumulator ignition, or both, being used. Cooling is carried out by a centrifugal pump, driven by silent pinions, in conjunction with a radiator of special design. Behind the latter is a fan driven by an adjustable belt. The carburettor has been made a matter of special study, and is of the float-fed spray type, fitted with a patented automatic valve, which accurately adjusts carburation for all speeds of the engine, and enables it to run dead slow. The accelerator pedal instead of operating the throttle direct, works it through the medium of a governor, which controls the speed to any desired extent, according to the state of the hand lever on the steering wheel. Pressure on the accelerator pedal, of course, opens up the engine in the ordinary way, one of the objects of the governor being to enable the gas to be shut off automatically when the car is descending a hill. One of the special features of the Rolls-Royce car is the silence of its poppet valves with their adjustable tappets, especially as these are not enclosed, and are not designed by any means to give what is called a "soft" engine. Only the greatest care in the machining operations of the cams, which are in one

piece with their shaft, could attain this result, and the same applies to the spur gear pinions, which drive the cam shaft and other parts of the engine. These work quite silently, and there is thus no need to use chains of any kind, with which certain inherent disadvantages are associated. The clutch is of the cone type, with a very large diameter and surface; the entering portion is covered with a special impregnated fabric which is practically indestructible with ordinary care and use, and is not affected by a considerable amount of slipping. The clutch requires very little pressure to operate, as the spring is of special pattern, designed to give practically constant pressure throughout its range. The connection from the clutch to the gear box is effected by a short shaft, fitted with an oil-retaining universal joint. The gear box is of the sliding type, furnished with a gate change, and gives four forward speeds, with a reverse, and direct drive on the top gear. The final transmission is carried out by an enclosed propeller shaft driving a bevel-driven axle. The whole of the weight of the car is carried on extensions of the back axle, and not upon the driving shafts, and needless to say all revolving components are fitted with ball-bearings. The thrust and radius stresses are taken by the tube surrounding the propeller shaft, which terminates in front in a large diameter spherical housing surrounding the main universal joint. The propeller shaft is supported by a central bearing, which eliminates any likeli-

hood of propeller vibration or whip being set up. The brakes, both foot and hand applied, consist of internal expanding shoes, operating inside large diameter drums attached to the rear wheels. There is thus no counter-shaft brake at all, and a special feature is made of the silence with which these brakes work. The side brakes are compensated by means of differential gears, so that when this is applied an equal distribution pull is ensured between both wheels. The steering mechanism consists of a worm working in a phosphor-bronze nut, provision being made for taking up all wear which can possibly occur. Ball-bearings are used throughout all the working parts of this mechanism, which operates peculiarly easily without any tendency to backlash. Rolls-Royce steering contributes considerably to the general "silkiness" of the car. An especially notable feature of the chassis is the suspension. This is carried out by the usual half-elliptic springs in front, and by flat, or more properly quarter, elliptic inverted or grasshopper springs in the rear. Each of these springs is carried on a trunnion in the middle, and is shackled to the axle in the front. At the rear it is provided with a slide, so that the whole of its motion is perfectly free and unrestrained. The suspension is remarkably easy, and is rendered all the more so by the standard fitting of shock absorbers of the frictional type. The Rolls-Royce chassis is priced at £985, and the Rolls-Royce justly claim that their showroom is perhaps the

only one in the world in which no customer enters unless he is prepared to spend a thousand pounds at least.

The 38 *h.p. Lanchester.*—The Lanchester car is particularly interesting, because its designer was a pioneer in motor design, and it is significant that many of the ideas which were incorporated in the first Lanchester car, produced many years ago, have gradually found more and more favour with rival manufacturers, such instances being magneto ignition, the worm drive, and the Lanchester form of springing. On the other hand standard design so called has not been without its effect upon Lanchester practice, and whereas the earlier cars made by this firm had horizontal engines, the latest pattern have vertical engines on more or less accepted lines, though they are full of notable individualities. A very important feature of the 38 h.p. Lanchester, which is in every sense a luxury car, is that the chassis will carry within its wheel base a commodious body that can only be provided on any orthodox chassis by overhanging the rear axle or by an excessively long wheel base. This is achieved by placing the engine in the foot space between the driver and front passenger, or, to put it more correctly, by moving the dashboard to the front end of the engine, placing the driver's seat where the dashboard usually is, and utilizing the space on each side of the engine; incidentally, this position renders the engine more accessible, and at the



THE SIX-CYLINDER LANCHESTER ENGINE. THROUGHOUT THE DESIGN GREAT INGENUITY AND PRACTICAL INDIVIDUALITY ARE EXPRESSED

same time the amount of space on the chassis available for body-work is very largely increased. The rear passengers occupy a position well in front of the back axle, and their comfort is consequently very much enhanced compared with their position on cars of ordinary design, namely, quite often a long way in the rear of the back axle. The bore and stroke of the six-cylinder engine are 4×4 inches, and the Lanchester has therefore one of the shortest strokes compared to bore of any car on the market. The cylinders are cast in pairs, and mounted close together on the aluminium crank chamber, joints between the water jackets being effected by plain rubber rings. The circulation takes place on the thermo-syphon principle, and is accelerated by a propeller form of pump mounted in the main water outlet pipe immediately behind the radiator. One notable point of the Lanchester engine is that the valves are horizontal, and are so arranged that they do not require any pockets, but open directly into the combustion head. This, of course, greatly increases thermal efficiency, and at the same time the design is such that both valves are very readily accessible. These valves are held on their seats by long, flat blade springs, fixed vertically, and are operated by a cam shaft on each side of the engine, which actuates the valve stems through long vertical rocker arms. This arrangement contributes very greatly to the silent running of the motor. The crank shaft is carried on seven

bearings, and is extremely stiff. The lubrication is effected by a high-pressure system of oil supply, under which the lubricant is forced directly to all the working parts by means of a hollow crank shaft and pipes up the connecting rod. Ignition is by a Bosch high-tension magneto. The carburettor is, like many other things on the Lanchester car, strikingly individual. It works on the wick principle, and is maintained with a supply by means of a float-feed arrangement. The carburettor is mounted on the petrol tank, which is under the front seat, and lies between the driver's and passenger's seat. The carburettor occupies rather a larger amount of room that the ordinary spray type, but the results it gives are eminently satisfactory in point of constancy of mixture under all conditions. The engine, gear box, and clutch are all bolted together to form a single unit, and the whole of their working parts is thus enclosed. The clutch is of the multiple disc type, and the gear box employs epicyclic gears, which give three speeds forward and reverse.

The gears are always in mesh, and consequently no harm can be done by lack of skill or carelessness in changing gear. These gears are operated by a gate change-speed lever, and the control is very cleverly arranged, so as to be similar to that of an ordinary car. At the rear of the gear box, and entirely enclosed and running in oil, is a multiple-disc counter-shaft brake, behind which is a main universal joint. The whole of the counter-shaft

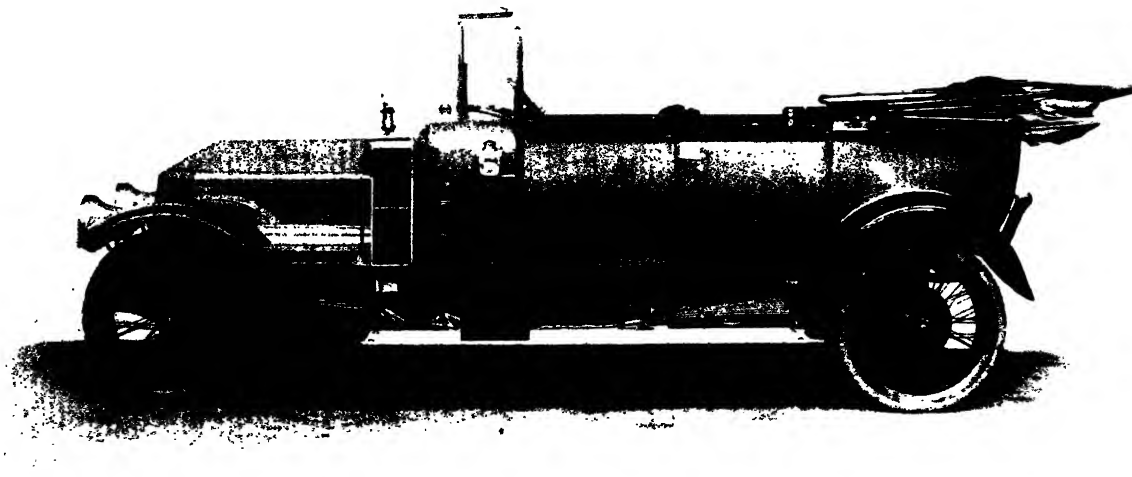
is supplied by oil from a special pump, which maintains it in constant circulation. The final transmission is carried out by an open propeller shaft, universally jointed at each end, and a worm-driven back axle with the worm pinion underneath. This, as mentioned above, is a distinctive Lanchester feature, and in fact the Lanchester worm, which is the only theoretically correct one, was the first of its kind to be produced. The hand brake applies the usual expanding shoes inside drums mounted on the rear wheel hubs, and there is in addition to this counter-shaft brake a third brake, namely, the reverse gear of the epicyclic train. When this is engaged it acts as a brake, provided the car is going forward, but if held in action after coming to a stop, it of course commences to reverse the car. Lanchester springing is, as has been noted in a previous chapter, rapidly coming into more general use, although all the firms which use its principle do not exactly follow the original design. Both the front and the rear axles are suspended by means of inverted half-elliptic leaf springs, whose fulcrums are in their centre, and fitted with a shackle in front and behind. The up and down motion of the axles is determined by two parallel rods, which are articulated each end, and which give the axle a parallel motion, which greatly reduces the grinding effect which takes place between the tyre and the road under the action of the springs. In the case of the rear axle these two rods act

as the radius and torque rods, sustaining both the driving thrust and the torque reaction, and thus leaving the springs entirely free to perform their function of suspension.

The steering is carried out by wheel in conjunction with a right- and left-hand thread and two half-plunger sleeves operating on a rocking lever. The hand controls of the motor, instead of being mounted on the steering wheel (which is of the folding type, to give easy access to the driver's seat), are arranged on a flat plate between the two front passengers. It will be observed that the rearward position of the engine in relation to the chassis of the Lanchester car results in there being a much better distribution of weight on the wheels than is usual, the whole arrangement being more symmetrical even when the car is carrying a lighter load of passengers than in the ordinary car. It is not surprising to find the Lanchester noted for its extremely luxurious running. The Lanchester equipment embraces a self-contained lighting and powerful engine starting set made by Messrs. J. Lucas & Co., of Birmingham.

The price of the 38 h.p. six-cylinder Lanchester chassis is £885.

The 30/36 *Six-cylinder Siddeley Deasy.*—The success of the 30/36 six-cylinder Siddeley Deasy is all the more deserved because the designers have entirely forsaken the well-trodden paths of so-called standard construction. Thus the car embraces all that is latest and most progressive



THE "COMPLETE CAR" AS TYPIFIED BY A SIX-CYLINDER SIDDELEY DEASY

in its various components. The engine is of the Silent Knight type, having sleeve valves, and manufactured under licence from the Daimler Company. The bore and stroke are respectively 90 × 130. The cylinders are cast in pairs, and are fitted with detachable heads, which enables any carbon deposit to be very readily cleaned from the combustion space. The cooling is by pump circulation, in conjunction with a vertical tube radiator, placed behind the bonnet and forming the front portion of the dashboard. The bonnet is thus totally enclosed against the ingress of dust and dirt, so that the engine keeps thoroughly clean in all circumstances. The crank shaft, which is carried on seven bearings, is furnished with a patent vibration damper in front. This tends to obviate any periodic vibration set up through torsion in the shaft. Mounted immediately over the damper, which is in effect a subsidiary flywheel, is the lighting dynamo, which is driven by belt. The lubrication system is carried out in a special manner. Underneath the crank thrust are separate troughs, which are fed with a supply of oil by a multiple plunger pump. The height of these troughs and the level of oil contained therein is variable, and as the troughs are moved interdependently with the throttle lever, it follows that the supply of oil to the working parts, which takes place by splash, is proportionate to the load on the engine. During its circulation the oil is very adequately

filtered. The carburettor is of the special Siddeley Deasy pattern, and is extremely simple. It has two jets, one for ordinary running and the other for slow running, and the control of the air is effected by an automatic suction valve contained inside the carburettor and forming practically a variable choke tube. The flywheel has large vanes attached to its periphery, which induce a strong circulation of air through the radiator. Inside the flywheel is a very simple and efficient form of single-disc clutch, a particular merit of which is that it is mounted on a universal joint in the centre of the clutch itself, so preventing any possibility of mal-alignment. The above-mentioned universal joint, and also the second on the clutch shaft, is of very neat type, and consists of a ball united to an internally fluted tube by half a dozen steel balls carried in cups. The gear box gives four speeds and reverse, and is operated by a gate lever in the usual way. The final drive is by open propeller shaft and worm-driven axle, which is slung on the Lanchester type of springs already described. The suspension in front is by half elliptics of the standard type. A special point in connection with the Siddeley Deasy rear springing is that the springs are adjustable to suit different loads.

The price of the 30/36 six-cylinder Siddeley Deasy chassis is £685.

CHAPTER V

THE MOTOR-CAR IN WAR

Motor-cycles—The motor omnibus in the German War—German armoured cars—Transport—Red Cross work—The Army Service Corps—Field kitchens

A HUNDRED years ago it was a famously favourite dictum of the great Napoleon that "an army marches on its stomach." The vicissitudes of warfare, the moves and counter-moves that science and technical skill have given rise to in that century have altered military methods almost out of recognition, and it is now held as a truism by many responsible authorities that if the phrase of Bonaparte is to be brought up to date, it can only be made so by a substitution of "motor-cars" for "stomach" in that immortal sentence.

Many and searching have been the reliability trials organized by this and that institution to attain some definite step forward in the progress of motor-car design. But as a reliability trial, *qua* such, as a medium for putting modern automobile construction to its ultimate test, as a foundation upon which it could be possible to construct a testimonial to actual performance, nothing of this

nature can for a moment be compared with the greatest war of all time. Those of us who have to content ourselves with waiting and watching rather than taking a hand in the shaping of these enormous events can have but little notion of the part that the motor-car is playing, has played, and will play in the campaign. Human bravery and endeavour, charge and counter attack, grenade and projectile, are more apt to be mentioned in despatches than petrol, but the role undertaken by the last named is nevertheless such that the conduct of a modern campaign in any corner of the world, but especially in Europe, is without it almost unthinkable. There is in fact no branch of either service—military, naval, or air—in which the self-propelled vehicle is not a factor of prime importance, and not only is this the case but it has its part no less in feeding the fighting line and picking up the wounded.

In round numbers there are about 6,000 motor vehicles of various types being used by the Expeditionary Force. This figure includes a considerable body of motor-cycles, the utility of which is confined, however, to the more specialized spheres of scouting, despatch carrying, and, in conjunction with a side-car attachment, the mounting of small machine guns. The drawback of the motor-cycle is, of course, that its proper and safe load is one person only, and this fact restricts its sphere of action to a decidedly limited extent. On the other hand, its mobility—or should I rather say, its manœuvr-

ability—have rendered it of the utmost service, and when the Book of the War has to be written it will be a prejudiced author who cannot concede a glorious chapter to the doings of the two-wheeled motor-car.

The value of the full-grown car it is impossible to exaggerate, for the widely divergent uses to which it has been put have rendered it almost ubiquitous. Here you find it, in the form of a motor omnibus quickly carrying a body of men from one place of strategic importance to another. When the Expeditionary Force was thrown, under cover of secrecy, across the English Channel, dwellers in London scarcely marked the diminution in the number of vehicles plying for hire in the streets. Those who observed that one had to wait longer for an omnibus or that taxi-cabs were not so plentiful as usual, did not perhaps at the time realize that these vehicles, usually so symbolical of prosperous human activity and enterprise, were, despite their labels of "Hendon, Cricklewood, Marble Arch, Oxford Street," etc., engaged in the sterner work of transporting column after column of eager fighting men to the scene of battle. Many a chassis whose wheels must by constant usage grow to know city streets almost by instinct has saved a situation of national importance, and if, overloaded, overdriven, and possibly shelled it ended its humble career in an ignominious ditch, it must none the less be respected as a hero amongst mechanical contrivances. It is, perhaps, as well for Great

Britain that though her cities have taken kindly enough to trams, the motor omnibus has been more encouraged than in any other country in the world, for at the call of necessity we had at command a fleet of well-tried vehicles almost unlimited in number. This thing has not been overlooked by the eyes of the commercial world, and the manner in which the heavy vehicle has performed a harder task than one might ever have thought would be allotted to it, has shown not only that Great Britain turns out incomparably the finest motor-cars of this type in the world, but that the time for regarding the industrial automobile as a problematical experiment is past once and for all.

In connection with the part that the purely pleasure car has played, and continues to play, in the war, it is necessary to point out that by the very reason of our insularity we as a military nation have not so early seen in it the possibilities of development it inherently possessed. It is not too much to say that Germany owed much of her initial success—and, such as it was, it was inseparably bound up with rapid mobility of armaments and weapons of attack—to the possession of a large fleet of armoured motor-cars, some of them of the heavy type, but for the most part consisting of an ordinary high-powered pleasure chassis carrying a suitable super-structure of armour with one, or even two, machine guns. These cars, admirably equipped, fast, and consequently almost invulnerable when on the move, and, let us concede, bravely

and skilfully handled, had a far-reaching and immediate effect. They could at a moment's notice be here, there, and everywhere, and as a weapon of attack they showed themselves quickly to be of amazing value. It is admitted that had there been more armoured cars available great use could have been made of them by the British Force, but on the other hand this initial shortage was of less consequence than would superficially appear to be the case. In the first place, the armoured car is of no great value as a defensive piece of ordnance, and it must be remembered that it was our first business to repel attack rather than initiate it. In the second place we gained time and experience in the construction of such vehicles, both of which factors have been turned to good account, so that within a comparatively short period we became as well equipped in this respect as the enemy. One of the greatest uses of the armoured motor-car is in connection with fighting against aircraft. Guns adaptable to this purpose are readily mounted upon an ordinary touring chassis, and so placed they possess a mobility and a range of orientation that no field piece could possibly hope to enjoy. Again, just as they are used thus against aeroplane and dirigible, so also are they employed as the indispensable ally of the newest arm. Loaded with spare parts, replacements, and fresh supplies of fuel and munition a car sets out to follow, as far and as fast as it can, every aeroplane that sets off on its journey of reconnaisance or attack, and to the

devotion and skill of those who were managing his tender upon the ground many an aviator owes his life, and many a machine has been rescued, to be put to further valuable use instead of being destroyed in hopeless despair by its ill-starred pilot.

As a means of pure and simple transport, the service to which motor-cars can be and have been put is obvious from a glance at the map, for how otherwise than with the aid of swift vehicles capable of travelling hundreds of miles on end could a commander have commanded a battle front that stretched three-parts of the way across France. Innumerable cars have carried the staff hither and thither, and have enabled distant points in the front to be linked up as no other means could possibly permit. Instead of being tied down more or less to its base, the General Staff has been enabled within twenty-four hours, or less, to travel from the centre to any other point of that wonderfully moving tragic line. Nearly all of the cars used for this vital purpose were voluntarily produced by the motoring public, and one learns that the majority are driven and looked after by civilian volunteers. In spite of all the calumny that has been heaped upon his head, the British motorist and his British car, despite the hampering legislation and persecution that it has had to fight against, has certainly "made good," and one's only regret is that whilst the limelight is focused upon them whose business it is to shoot and charge, the doings of the many

brave men behind the steering wheel have been cast into shadow.

To a certain extent one premises, from a description of its uses in the field, that the motor is an exceedingly active weapon of war. Yet it constitutes at the same time an agency that has done, I write it advisedly, more than anything else to alleviate the discomforts, the trials, and the rending horrors of human warfare. It is impossible to render too high praise to the service performed by ambulance cars all over the war area. Under the auspices of the Red Cross Society, these vehicles —a very large proportion have been furnished by private individuals and subscription lists—have gone about their errands of mercy with a reliability to which many a poor wounded soldier owes his life. They have been on the spot, even in the midst of the din of battle, to pick up the injured, to convey them first to the field hospital, and afterwards to a base, and in the interior of their none too roomy bodies many a skilled surgeon has continued to bring some pressing operations to a successful conclusion. It is, perhaps, rather a bitter pill which the English manufacturer has to swallow, when he realizes that in connection with field ambulance work no car of any nationality has shown up so well as the once-despised Ford. Its lightness—and the fact that its engine has plenty of reserve power —has enabled the Ford to go into places to which the more thoroughbred type of car could only be got with the greatest difficulty.

The grand work accomplished by the Army Service Corps in supplying the fighting-line with food, ammunition, and stores may be ascribed very largely, without in the least detracting from the bravery of the men who manage them, to the fleet of motor vehicles wherewith it is equipped. In spite of the worst possible traffic conditions, in spite of roads ploughed up with rain and the passage of monstrous guns and the thousands and thousands of troops, in spite of bridges blown down and culverts wrecked, lumbering lorries, well-laden vans, and swift cars have one and all kept their appointments with amazing punctuality. From rail-head to rendezvous they have gone steadily to and fro, burdened with comforts and necessities for the fighting man, and no greater testimony to their value could be imagined than the oft-quoted statement that the man in the trenches was never so well fed before in his life. More recently the value of the motor-car has been still further expressed by fitting chassis with field kitchen bodies. Pulled up under the lee side of some "cover," and within a few yards of the trenches themselves, what was once a luxurious touring-car chassis now supports a body somewhat resembling a coffee-stall, and within busy hands prepare hot meals for Tommy Atkins.

Thus one sees how in every phase of war conditions, no less than in civil and peaceful life, the motor-car has its manifold uses, so that within a comparatively few years it has developed from a vehicle of problematic luxury into something

absolutely indispensable, and those who once wondered if the motor-car were a passing phase only or had come to stay, now ask, if only as a result of reading about some battlefield, " However did we manage to do without it in the past? "

CHAPTER VI

THE OPEN ROAD

FIRE IN THE HEART OF ME, MOVING AND CHATTERING,
YOUTH IN EACH PART OF ME, SLENDER AND STRONG,
DEATH AT THE FOOT OF ME, RENDING AND SHATTERING,
LIGHT AND TREMENDOUS I BEAR YOU ALONG;
UP TO THE BROW WHERE THE LEVELS GO WEARILY,
DOWN TO THE VALE WHERE THE GRAVELS GIVE SPEED,
HOLDING IT, MOULDING IT, SCOLDING IT CHEERILY,
SLAVE TO YOUR PURPOSE AND SIGN OF YOUR NEED.

SLENDER THE SPOKE OF ME, DRIVING UNCEASINGLY,
DREADFUL THE YOKE OF ME, MIGHTY THE STRAIN.
YET SEND ME NOT WHERE THE WORK LESSENS EASINGLY,
GIVE ME THE LIFT OF THE ROADWAY AGAIN.
FEAR, THEN, NO HILL THOUGH IT RISE TO FUTURITY,
HEED NOT INFINITY; BE NOT PERPLEXED;
SOON AS ONE ÆON HAS GONE TO OBSCURITY,
HEY, BUT I'LL RALLY YOU INTO THE NEXT!

G. STEWART BOWLES, *The Song of the Wheel*

I

THE true home of the motor-car is not in garage or workshop, showroom or factory, but on the open road. There it comes to its own, there it justifies itself, there it fulfils its true and appointed destiny. Like a captive lion or a savage shown at a fair, it makes a poor enough

appearance out of its true environment; and when we see it quivering at a standstill or fretfully hanging in the crowded lanes of street traffic we sometimes think very poorly of it. But away from these entanglements it comes into the noble kingdom of which it has so lately captured the throne. The miles, once the tyrants of the road, the oppressors of the travellers, are now humbly subject to its triumphant empire, falling away before it, ranking themselves behind it. The wand of its power has touched the winds to a greater energy, so that the very air it consumes is crushed upon it with a prodigal bounty, sweetened with all the mingled perfumes of the fields and the seasons. It flattens out the world, enlarges the horizon, loosens a little the bonds of time, sets back a little the barriers of space. And man, who created and endowed it, who sits and rides upon it as upon a whirlwind, moving a lever here, turning a wheel there, receives in his person the revenues of the vast kingdom it has conquered. He lives more quickly for its vitality, drawing virtue and energy from its ardent heart; and if it be true that the capacity of life in each of us be limited not by time but by quantity, and that the mysterious engines of our flesh and spirit are set to endure, to enjoy, to see, to understand, to know, to live only up to a finite limit, then man's days, being faster and more crowded, will be fewer; and we shall find that what we received as a gift we shall be called upon to pay for out of our scanty store of years.

II

But even if it should threaten to rob us of a few of the melancholy days of old age, this new slave of ours has won back for us the roads. "The nerves and sinews of the land," Mr. Strachey has finely called them; and they are like nerves and sinews long disused, that are beginning to twitch and swell again with the message of life. Already on the great main roads the thrill of vitality has been felt. Old inns, that had long slumbered in a kind of ruinous trance, are beginning to wake up again, to bestir themselves, to be prosperous. Old men and women, keepers of shops left high and dry by the ebb of custom, who had thought to end their days in poverty or the workhouse, are here and there, to their profound astonishment, finding themselves afloat on the rising tide of prosperity. It is due not only to the direct influence of the motor-car, of course, but to the new impulse of movement, of travel, and of intercourse of which the motor-car is at once the agent and the herald.

And out on this world of roads the traveller on a motor-car enters into possession of his country in a new way. In railway travel only two points are of real importance—the points of departure and of arrival; all the rest is but an accessory of the railway, a panorama of embankments and cuttings and curves at which we give a mere glance now and then. Things seen are seen only in their relation

to the railway, of which, with its manifold and tremendous organization, we can never be quite unconscious. It absorbs our individuality so that we are whirled along in an embarrassing cloud of companionship; all our fellow-travellers, the guards and enginemen, the clerks in far-away traffic offices, the signalmen reading by their cabin fires, the invisible and scattered army of cleaners, turners, shunters, lampmen, platelayers, and carriage inspectors, are all conspiring and collaborating in our punctual journey; and in such a degree that if thought or will-power could be confined and controlled in bulk, the train would need no other engine than the labours and wishes that are concentrated upon it.

But the road sets us free from this marvellous complexity of thought and mechanism, allows us to follow our own choice as to how fast and how far we shall go, permits us to tarry where and when we will. Moreover, it restores to our journeys their true value and importance, making them not a matter merely of departure and arrival, but of deliberate and conscious progress, in which every mile, every yard, is of equal importance with the beginning and the end. To walk by road is to taste this deliberation of travel in its full flavour, and to make of each footstep a stage in the journey; by motor-car we lose the extremely minute detail of the road, but cover it in spans so much greater that the sense of passage is vastly increased. And this, I think, is the supreme charm

of this kind of travel; that it takes us from one world to another, not as the railway takes us, sealed up in an envelope containing ourselves and our environment, but open to and conscious of the things that connect those worlds with each other, so that we see the change coming and know how it has come. We do not shut our eyes in the plains to open them again on the mountains. We feel the road rising under us; we pass from the shelter of the valleys to the winds of the uplands; we leave the placid land of willow and poplar, and rise to where the pines and firs are waiting on the sky-line; we wind up and away from meadow and cornfield to where moss and heather crowd among the rocks; we strike into the colder mountain air, the bare and austere mountain world, away from trees and heavy flowers and chattering birds, to where only the bees and the larks make music, and where the little flowers, hardy and wild and fragrant, lodge among rocks that the sun has warmed.

III

A day's journey on a motor-car is not merely a piece of travel across the spaces of geography; it is often a voyage through the life and history of the land. Perhaps you pass across the Weald of Surrey and Sussex, where once the forests were thick, where later the smoke rose from a thousand fires and the land was blackened with the industry of smelting;

but where, in our own busy and clamorous age, the ashes of that forgotten toil are folded in the deep peace of fields and gardens. Or you may fare along the Roman roads—those ways made sacred by the passage of immemorial hosts, of conquering armies, of all the pedestrian life that in years gone by came to its twinkle of existence in our country and vanished like smoke. Or you may set forth of a morning from some great modern city humming with commerce and echoing to the strife of politics and exchange; and you may draw up as the sun sets in a little town perched above the sea, where the quays, deserted by commerce, resound to cries of the little barefoot children of sailors. Yet they are not ordinary children nor ordinary sailors that you will meet on this narrow street by the harbour, but fair-haired, blue-eyed babes showing beneath grime the strong features and bright eyes of the Dane; and tall, deep-chested, big-boned men, with the same childish eyes and tangled yellow hair — sons of Norsemen and Vikings, cast up in the dusk of their race on these neighbourly shores.

And wherever you pass on your journey the road tells you the story of the people who live beside it. To drive from London to Chester is to be instructed in the character of the great divisions of England. The rich sleepy life of the south is traversed by the road that runs wide between the sunned and weathered houses of a dozen High Streets, sheltered by great and ancient trees, and skirting for miles

the boundaries of many a vast feudal estate. You pass through the shires and the Midlands, where the world seems to consist only of fields and sky and trees, and where, lost amidst this pastoral wilderness, you wonder what has become of over-crowded, town-devoured England. Yet a little while, and you are plunged in the grime of the Black Country, where the trees are stunted and the vegetation poisoned, and where the smoke of a hundred industries darkens the sky. Again a little while, and you are back in a smiling land and speeding on through a country that is subtly different from that of the earlier miles, where something in the build of the houses, in the disposal of the villages, and in the very faces of the inhabitants tells you that you are in the north. And in all your passage through this changing scene, in the glimpses you get through open doors of a family at dinner, a child at play, or a horse in his stable ; in the attitude of women who stand at the doors shading their eyes to watch you go past, or in the sight of a tired labourer trudging homewards at sundown, you are reminded of the eternal difference in point of view between the traveller and the resident, between those who have their continuing city in the small world that represents but a moment in your impassioned journey, and those who, in their relation to that world, are only wayfarers and strangers.

IV

There is still here and there an opportunity of seeing the invasion of this new force upon virgin soil. In the early summer of 1904 I went to the Isle of Man to see the English Eliminating Trials for the Gordon Bennett Trophy. Three racing cars were to be chosen to represent their country in this international contest, and the eleven aspirants for that honour were matched against each other in a road race hardly less long and severe than the great contest itself. But interesting as the race was by virtue of its chances, its immense speed, and its almost incredible safety, it was not so interesting as this sudden descent of all the mechanical furies contained in a dozen racing cars upon a virgin island, girdled for ever by the unchanging sea, folded as yet in its peaceful slumber of winter and spring, and not yet aroused to the unlovely commotion of tourist traffic. A dreadful interest, a profound mystery, overhung these machines in the contemplation of the populace. Lurking within their dens all day, for they were properly forbidden to scour the roads during waking hours, they aroused themselves at early dawn and awoke for a few hours of their terrible life. With the first of daylight they would come forth, trembling with restrained passions and emitting thick streams of explosions upon the quiet morning air. Their masked and swathed directors, sitting bolt upright

on their frail seats, controlled with a turn of the wrist the forces that presently hurled them inland up the mountain road, leaving the few early risers in the market-place stupefied by the sudden silence.

And they were far from docile, these monsters; far different from the obedient and responsive creatures that carry us on our country journeys. Each represented the last ounce of brute power that the builder dared to contain within a light and frail carriage. To drive one of them was no easy task, but a prolonged battle with the terrific demon that, only half-tamed, raged within the cylinders. Some of them would not travel at all; there was one ill-starred brood of three that had their lair in a shed upon the harbour wall, to whom all day and all night an army of foreign mechanics diligently ministered. At intervals their toil would reach a point at which the result might be tested; the starting handle would be manned, and the monster waked into life at the cost of a dislocated wrist. Then a dread commotion indeed would echo among the rocks. A rattling crescendo of explosions, a blinding sheet of flame, with, at short intervals, a detonation like the report of a heavy cannon, would bring the townspeople of Douglas running to their doors. They would scan the horizon, as though to look for a bombarding fleet or a volcanic eruption of their silent mountains. But no; a little group of workmen surrounding a low, slight, motionless machine mounted on low wheels were all the

centre of this tremendous and elemental uproar. Now and then, indeed, labour would be so far rewarded that the chariot of fire might be run along the harbour wall, the fascinated crowd scattering before its swift and deafening progress; but in a few hundred yards it would be pulled up, or else its giant pulses would mysteriously die down. And all day long and everywhere the presence of these few cars brooded over the island like a doom. In the towns people crossed the streets quickly, with an eye over the shoulder for the delightful, thrilling terror that might at any moment (so they thought) rush out upon them; and up in the inland fields men strained their ears to hear, amid the whisper of the waving grasses, the increasing pulsation that might herald the lightning passage of that which bewildered the eyes and made the heart quake.

V

On one of the racing cars, by favour of its master and tamer, I took a cramped and precarious seat on a morning before the sun rose. The houses of Douglas lay blind and silent in the dawn; the gas lamps burned almost invisibly; and as we rushed along the promenade our echoing progress was through a city of diurnal sleep. There is about the dawn a solemnity and strangeness that no familiarity can change; but though I have seen its magic panorama from city streets, from the sea, from sub-

tropical tablelands, in all sorts of places and conditions, it has never seemed to me so new and so mysterious as on that morning in the Isle of Man. All round us the world seemed to lie asleep, the sea dull and grey and still under a soft muffled sky; only we seemed alive as, seated on our infernally potent machine, we clove the stillness and tore through the silence. In twenty minutes we covered nearly as many miles of the island road; now the sea was behind us, now it rose before us as, having spanned the breadth of the island, we hung over the little town of Peel; a little later we were at Ramsey, and could see England and Scotland and Ireland rising out of the morning mists. And there seemed to be but three conditions of our existence: the land, like the island of a dream, empty, deserted, silent; the slow and solemn scenery of the morning, unfolding itself on the world in a glory of fire and colour; and the weird creature of iron and steel that swayed and chattered and flew beneath us. The ineffable thrill and exhilaration of such a flight none but they who have experienced it in their own bodies can ever conceive. It is beyond everything else in our physical existence. It is the exaltation of the dreamer, the drunkard, a thousand times purified and magnified. It is not mere speed, for that may be equalled on an express train without any like effect. It is, I think, a combination of intense speed with the sensation of the smallness, the lightness, the responsiveness of the thing that carries you, with the rushing of the atmosphere

upon your body and of the earth upon your vision. The road, twisting and wriggling before you, streams endlessly under the wheels; the trees fall into advancing ranks; the very mountains, that in half a day's walk do not seem to change their places, move and wheel and curtsey round you in a stately dance. The tremendous detonations of the engine are silenced by the uproar of the air to a rhythmical beat, as the fires at its heart are cooled by the same pure stream; the road itself has a note, and every stone, telegraph post, and house that you pass close by makes a sharp sound, like the whizz of the Mariner's cross-bow. And to your exalted, expanded senses the noise of movement is heavenly music, the wind like wine of the gods.

VI

Once we stopped, drawing up by the fragrant roadside; and as the pulses of the engine died away, so died away the strange sensation of giant, divine life with which its breath had endowed us. No longer gods, we stood under a clump of hawthorn and gave ear to the first faint voices of the birds. Inert and dead reposed the magic carriage, all its fiery energy dissolved, helpless to move itself an inch, its devouring life resolved into a few hundredweights of metal, a few gallons of petrol, a few coils of wire, a few handfuls of salts and acids. In place of the rushing exhilaration of our

stormy progress, the quietness of the morning now stole upon our senses. The road lay full in our view for a mile on either hand, empty. The great overture of the skies was nearly ended, and the eastern fires, now changed from saffron to gold, were gloriously revealed as the curtain of cloud rolled away. The sun began to warm the chilly air and, striking on our backs, threw our mile-long shadows on the road. And as we thus stood we were presently aware of a far-away throbbing sound that increased evenly from a drone to a weird cry—the sound of a racing car at full speed. A speck appeared over the edge of the distance, rapidly grew and took form, and then in a flash one of our monster's rivals came up, went roaring by with its two crouching, wind-bitten occupants, and was gone in a whirl of dust. The one glimpse we had of the driver showed a man with an adamant face, his hands clinging like steel to his steering wheel, his white overall flattened in front and distended behind by the wind. He came and went like an apparition. The moment after he had gone one could scarcely believe that he had been there, but his whirlwind passage left an impression that was at once startling, intoxicating, appalling. That is what it looked like—a shocking, death-challenging performance; and yet we who were familiar with it, who had but a moment before alighted from a similar flight, knew that the adamant face represented only concentration; that behind it there lay a brain perfectly cool, perfectly attentive; and that

within the storm of noises and tempest of the nerves there existed a calm, an exalted, a serene contentment.

VII

And presently, while we still waited in the coolness of that early May morning listening to the birds that now began to sing more heartily, there fell on our ears another signal, this time of sinister portent. Far away among the fields of the lower valleys, like the firing of heavy guns, resounded the first of a series of echoing detonations. We looked at one another: "One of the Arrows," we said, naming the terrible but unlucky brood that had their habitation on the Battery pier. Herculean efforts, it appeared, had awakened one of these to the dread environment of the road, and it was even now on its way; but so fiery was its pent-up passion, so intemperate and greedy its frustrated appetite, that one out of every dozen or so of the inspirations of its lungs was gulped down raw, to explode in its bowels with a tremendous report. It must have been three miles away when we heard it first, for several minutes passed before the explosions, instantly increasing in volume, became so deafening as to assure us of the immediate arrival of the machine. Then it appeared, growing, like the insect of a nightmare, enormously bigger and louder; slowed down and drew up beside us; and, for once obedient to the will of its driver, roared

itself out into quietness. Then we were able to speak to the man and hear the tale of his journey. It was wild enough. He was covered, even to his face, with oil, which was flying up out of some neglected orifice; his frail seat had given way beneath him, and he was shaken and bounced precariously over the fatal chains and wheels of his charge; the covering of a metal switch controlling the passage of electric fluid to the vitals of the engine had come off; so that even to modify the speed of the insane projectile upon which he rode, he must instantly keep pressing his thumb upon the sharp and lacerating point of the switch, receiving an electric shock as well as a flesh-wound every time. "It isn't as if I had nothing else to do," he remarked, with singular moderation, as he wiped the oil and sweat from his face and the blood from his fingers; "but at any rate she goes!" And he turned again cheerfully to his really appalling task. The engine was restarted in a clap of thunder, and with a six-foot flash of yellow flame the car rushed away, booming like a minute-gun long after it was out of sight.

Insane and vulgar, you might be tempted to say of this unflattering portrait; but you would be very far wrong. The man was wrestling with a giant—"fighting his car," in his own vivid phrase; and he was fighting with a remorseless, a gigantic power. He was there to tame it, to bend it to his will, to conquer or be conquered by it. He was taking his part in the great breaking-in of this new force that

will presently serve us universally and with complete docility—a thing, surely, a thousand times worth doing. He was one of the new race that has risen up for this formidable campaign, a giant in strength, a lion at heart, a good fellow in all human relations—in a word, a man entirely fitted to fight and wrestle with untamed machinery. Twenty years ago you would not have found men with the coolness, the nerve, the physical strength and brain endurance necessary to drive and steer along the country roads at seventy miles an hour an erratic and imperfect carriage; now they are with us in plenty, although it is rare to find them perfectly equipped. Such a one, I think, was he of the bloody hands and oily face; such a one is certainly my companion of that morning, beside whom, perched among the flimsy girders of his quaking machine, I sat as safely as in a garden while we took the road again, climbing up the cold breast of Snaefell, chattering round corners and among the rocks of the mountain road, skimming again down the great spiral track, with the birds flying below us and the level floor of the sea rising up round about us. It is something more than a whim of mine to believe that a very definite human virtue resides in the ability to meet all these risks smiling, and to turn them into safety; and when we drew up at our journey's end that morning, and the intent angle of his broad back was relaxed, I knew that my friend had a good human heart.

VIII

Of the race itself, which differed little from other motor road-races that I have seen, we may pause to take one glimpse here. There is no form of sport that seems quite so inane to those who merely read about it as a motor road-race, with its confusion of circuits, its controls and neutralizations, its vexatious details of minutes and seconds. Yet for those who are present and who follow the fortunes of the competitors throughout their arduous day there is interest enough to keep the mind entertained and the imagination busy. For though perhaps only once in an hour and a half do the watchers at any one point catch a glimpse of each competitor, the intervals are full of expectation, of flying rumours, of winged fragments of news that travel in some mysterious and unknown way across the hills and valleys from lonely parts of the course. That a competitor should have suffered a punctured tyre or a broken chain twenty miles away will sometimes be known at controls where no telegraph wire is tapped, and whither no merely physical agency can have carried the news; and known at a moment impossibly soon for any normal means of communication. One accepts it all as a phenomenon of the quickened atmosphere in which these giant infants of the human brain live and move, the radiant energy, both of mind and body, that infects all who approach them.

Regard one single instance of its working. At a control established in some wayside village, that yesterday slumbered over its sunny and deliberate occupations and to-morrow will gratefully return to them, stands a little group of officials with their paraphernalia of papers, stop-watches, reports, and time-sheets. The road, curving round into the village, is flanked by sightseers encamped for the day. On one side is a depot for pneumatic tyres; on another a whole engineer's establishment from London or Birmingham, with its attendant army of mechanics. Only the road itself is empty, lying white and expectant in the sunshine, carefully guarded by barriers, ropes, constables. All the ordinary village sounds are stilled; the smithy lies cold and idle, the shops are shuttered, the rumbling farm carts are laid up in their sheds; there is no sound but—the strangest of all sounds to hear about an empty road—the low continuous buzz of talk. The papers on the official table flutter in the breeze; the officials, tired of comparing their vast array of figures, talk in desultory groups; the mechanics are stretched on the warm ground, resting; and thus the scene remains for a little while until the telephone bell tinkles, galvanizing the official group into attention. The murmur of conversation swells for a moment as the name of the coming competitor is passed along; the dozing mechanics rouse themselves; the tyre repairers fall into an ordered readiness; and then the throng settles itself to silence for a moment. They are

listening. Far away, nearer, nearer still, sounds a steady throb; a pillar of dust like the smoke from a field-gun rises from behind the near hills; and some seconds after, arriving like a giant projectile from the same gun, the long, low car rushes with a scream of brakes up to the line. In a moment sound and commotion surround it; it is enveloped in a cloud of officials and onlookers, smothering their voices in the uproar of its engine. The times are taken, the stop-watches set going, and it moves forward to the repairing station. The beast is maimed; it is thirsty; its begrimed directors, unable to make themselves heard above its defiant bellowings, gesticulate and point to the wounded part. Mechanics throw themselves on the ground beside it, crawl beneath it, lie with upturned faces close to where all the wild powers of fire and steel are rending its heart with shattering explosions. On its tyres, hot with all the hatred of the spurned miles, are thrown glittering cascades from a dozen pails of cold water; into its maw is poured gallon after gallon of fluent life, limped as summer dews, dreadful as the caverns of Vesuvius; attendants minister to the needs of the driver and his assistant, who, seated on their reverberating platform and well-nigh drowned beneath the deluges of water and petrol, receive indiscriminately sandwiches, champagne, apples, chicken, and concentrated foods. And all this deafening and passionate activity lasts only for a few seconds. As the last mechanics scramble from beneath it the mighty

engine, now refreshed, grips the transmission shaft; the car bounds away; the stream of explosions fades in the distance; the crowd in the control returns to its quiet conversation; and only a dozen green petrol tins, a pool of water, a broken champagne bottle, a half-gnawed apple, a piece of sponge-cake soaked in wine and petrol, and a banana skin lying in a puddle of oil, mark the scene of this momentary and monstrous refreshment.

They see not the whole of this picture who regard it as a signal of vulgar and extravagant folly. Among the onlookers and the cloud of parasites that buzz like flies round the commercial honey of which each car is a centre, there are doubtless many dull, greedy, and partly insane persons; but never among those who work, whether they stand for ten hours in sun or rain at a wayside control toiling at advanced mathematics, or storm along at the extreme of speed for the same ten hours, or lie on their backs with the inventors in pools of oil, petrol running into their eyes, brute metal at a red heat menacing their faces. Ah, no; in the labours of these there is something Titanic, something of the dignity that invests all worthy battles fought against heavy odds, something of the fragrance of enthusiasm, the glory of the pioneer, the nobility that crowns all those who work for to-morrow. For among them they are discovering, moulding, teaching, adapting, and tempering what we may call the character of the motor-car—a profound and singular personality, full of life and power.

IX

But we have perhaps pored too closely over the wheels and cranks of the machines themselves, and delayed too long our return to the open road; and in doing so we have but fallen into the common fault of forgetting, in contemplating the means, the end for which our fascinating slave was called into being. But once on the road it ceases to be a mechanical study and becomes part of ourselves—an executive part that answers our will and carries us whither we would go. And there is its proper place, that is its proper mission, apart from which it can only be imperfectly understood. A ship lying upon the foul waters of a dock, unmoved by the tides, unvisited by the sea breezes, is often but a sordid thing, dark and stuffy and evil-smelling. But see the same ship when she is in her own place, when the blue seas heave under her, and the trade winds hum in her rigging. How pure she is then, how properly adapted for her purpose; how the sunlight searches all her corners, and the salt airs make fragrant all her spaces! So with the motor-car; if you would appreciate it, you must take it to the open road; and really to know all its virtues you must drive it yourself, become one with it, establish between it and yourself that sympathy which is perhaps the most enchanting of its qualities, and is really the secret of effortless control and mastery.

At first the road will alarm you by its panorama of risks and escapes; then it will exhaust you with its unending claims upon your attention and interest, so that at the end of a day your mind will refuse to desist, and will go on directing your progress; and, finally, it will hypnotize you and implant in you that restlessness, as haunting as the *heimweh* that is its opposite, with which it draws back to itself all who have ever fallen under its sway. This passion for the road is a far from new thing—it is one of the oldest things in the world. But it is new in its intensity; and I can imagine, when the first generation of motorists shall have passed away, their spirits haunting for ever the highways that first enthralled them, and ghostly puffs of dust travelling by themselves throughout a long summer's day, and the wind of an unseen passage fluttering the heaps of autumn leaves by the wayside. And so I doubt not that when some of us who have fallen into this bondage lie a-dying, the last image of the world present to our minds will be the picture that thousands of miles have photographed on our memory; of the road stretched white and narrowing, of the trees hurrying to meet us, of the snug homesteads left behind in the dusk, of the eternal Unknown that lies just beynd the turn of the road.

X

Of all the roads that ribbon England none is more alive, or has a more engaging personality, or

expresses more clearly the spirit of the road, than Telford's great highway from London to Holyhead. Made for endurance, it has long outlasted its first purpose, until in the fullness of time that purpose has been restored to it, and once more it is in use from end to end. No longer a mere chain of short links connecting hamlet with town, and village with city, it has come again, by wonderful revolutions, to its ancient dignity. Modern ingenuity has breathed on its slumbering spirit, which in these latter days has waked again to the bustle of life, the song of wheels, and the great business of travel.

So many roads set out bravely enough and lose themselves in a tangle of crossways and bypaths, all their purpose dissipated, all their promise unfulfilled. But this is a road that sets out and arrives. Even while it is still within the influence of London its purpose is obvious to the traveller. Or rather, it is obvious that it has a purpose; a profound and determined, and yet a mysterious, purpose, as of one who should say: "I have set out upon a long journey; follow my guidance to the end and you will see what my purpose is." Even in these early stages, when its milestones bear such a legend as "Potterspury, 2 miles," the noble breadth and long straight bearings give the lie to an inscription so local and so petty. Obviously it has no concern with Potterspury. It does not go to Potterspury; it passes through it. Its purpose is serious and ultimate; but not until you have followed its every

mile and the road stops on the edge of a sheet of green harbour water do you realize what that purpose was—why the road ran so straight through Daventry, why it did not mind going through Birmingham, or being soiled by the dust of the Black Country. For even when it was at Stony Stratford, it was the Holyhead Road, the road to Ireland. In its most dallying moments, looping round some pretty tree-clad hill or dipping into a valley sweet with sheltered flowers, it still meant to arrive; the dalliance was only momentary, only apparent; the ultimate purpose continually present and manifest. I speak as if the road moved and not the wayfarer; and perhaps the accurate man will quarrel with my paradox. Nevertheless it is one of the simple truths which accuracy is most apt to miss. In all our talk of roads this movement is taken for granted; all our verbs are active. The road comes from this place; it leads to that; it is a fast road or a slow road; it climbs hills, drops into valleys, crosses rivers, runs beside railways; andin all this speech its rippling, moving habit is illustrated. It is the road that really moves forward; at most the traveller follows it, lagging ever behind. For he never overtakes the road; it is always before him, just round the next corner, wriggling away like a snake from his pursuing wheels, always cheating, always beckoning, always eluding him, always going on.

The spirit of Telford, the man who dealt with flints and granite, hills and valleys, fields and rivers,

and turned them all into miles, resides in his Holyhead Road. So much of honest labour does not die, but takes in the passage of years a character and personality of its own. One is tempted to moralize about the travellers upon the road; all the toiling feet, all the dusty wheels, all the hearts, sad and happy, that have passed that way and made sacred its ancient stages. The Romans in their day of pride; the armies, victorious and fugitive; the jolly-hearted travellers by coach in winter; the lovers trembling through the scented starlight of a May night—these all used the road, but are vanished out of its life and memory and have left not a scratch on the surface. It is no monument of theirs; it is a monument only to those who made it, breaking new ground here, taking in a length of time-worn highway there; surely a monument most stable and enduring. For all time—or so it seems to creatures of a day—its mark is set across the face of our island, recording, like a finger-post, one of the ant-like trails of human activity. Its daily history is an epitome of human life, for on its stage are daily performed all the acts in our brief comedy; daily it bears the physician to the bed of birth, daily the bridegroom hastens along it to meet his bride, daily it sees some hopeful heart set forth on his life's adventure, and daily its dust is stirred by the tramp and shuffle of feet moving to an open grave. All through the night, while we are snug in bed, its surface lies silent in the moonlight or glistening rain; but throughout the longer night, when we

shall be no more interested, it will remain the scene of primitive effort and joy and grief, and resound still to the rumour of labour and of life.

XI

Secure in its purpose, the Holyhead Road can afford to take on the colour of its surroundings. When it is in Dunstable it does as Dunstable does, spreading itself out as though land were of no value, and as though sunshine and a reposeful expansiveness were all that a road could desire. But it wears a different face far away in bleak Anglesea, where its miles are laid as a thread over stony moorlands; or where it cuts through the living rock, or spans the clear green waters of a sea strait. Strong in the sense that it is a national and not a local road, it speaks different languages in the course of its varied career. It can be as modern as Birmingham and as ancient as Pentre Voelas; it can be as dignified as Dunstable and as mean as Weedon; it can be as terse as Chirk or as redundant as Llanfairpwllgwyngyllgogerchwyrndrobwlltysiliogogogoch. And safe in the knowledge that it is the Holyhead Road, it does not observe a timid exclusiveness, but now and again shares a stage with other roads of suitable dignity. Here it borrows a mile or two from its great brother, the North Road, there keeps company with its Roman ancestors, Watling Street and the Old Chester

Road. It is at once catholic and distinguished, generous and thrifty, cheerful and serious. Of the lesser highways that come to salute its glorious progress all are made welcome, whether as tributaries or borrowers; roads that come rushing pell-mell into it down a steep hill, roads that sweep grandly away from it and end foolishly in a cattle-yard, roads that steal away for an almost parallel hundred yards, and then suddenly and hastily turn off at right angles. Great and small, broad and narrow, they are all admitted to its company, with one single and significant exception—the shining steel way that once robbed it of its glories and left it for years lonely and deserted. From contact with this despoiler it now keeps itself inviolate. There are no level crossings on the Holyhead Road; the railway may soar above it or burrow beneath it, but may never again meet it on the level.

XII

If, winged with the modern magic, you use the Holyhead Road you cannot fail to be cheered by a great company that keeps with you throughout the miles. I speak not of the trees, but of those more constant flankers of a main road, the telegraph posts and wires. You first become impressed by the majesty of their companionship as the road leaves St. Albans. Before that, if you approach the Holyhead Road as I love to approach it, by

the winding, hill-tossed way from Edgware through Elstree, you will have noticed a single rank of wires here and there hurrying to the great tryst; and as you pass through the streets of St. Albans they begin to crowd together, by twos and fours, coming, you would think, from nowhere, flying in all directions over the ancient roofs of the town and past the chimneys and weather-vanes like gathering rumours, or like flurried passengers making haste to be in time. And then, as you turn the corner out of the town, you come upon the first of those mighty twin posts, braced and stayed against the pull of eighty wires humming steady organ harmonies in the wind, upon which all the convergent threads of news are ranked for their northward march. Oh, but they are brave companions, singing their song in the breeze, pointing the way far ahead up the mountain road, and for ever ranking and drooping and streaming, and starting up and swooping down beside you! Once, near Bangor, you lose them for several miles, and cannot see them on either horizon; but suddenly they rush upon you again from behind a hill, as though they joyed in the reunion after pursuing some short and steep cut of their own. And fast as you fly, the messages of good or evil news, of fortunes won or lost, of lives begun and lives ended, are flying faster along the wires; and far as you follow the road's course, they are diminishing in number, dropping off to finish their journey (so grandly begun) at some wayside village. For of all the

company that marched through Dunstable in double ranks on each side of the road, two posts abreast and forty wires to a post, only two keep faith with the road. These are the two that, when the last miles have been entered and the journey has resolved itself into a dream of miles and speed and a wind laden with honey and roses, go with you down the long straight ribbon over Anglesea to where the sea plunges under the cliff and the gulls cry about the lighthouse. For the wires are the Holyhead wires, although you could not distinguish them among the throng at St. Albans; and the wires dip under the sea and go on to their promised land; but the road?—The road to Ireland, for all its earnestness and splendid purpose, pauses for ever on the edge of Wales, and resigns its charge to the waiting ships. . . .

In a play by Mr. Yeats a dreamer says: "The roads are the only things that are endless." To which a matter-of-fact person, unconsciously expressing a still greater dream, replies: "Yes, but even they have to stop when they come to the sea."

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5/1/16